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To Richard Taylor Esq^r F. L. S.
from the author

BOTANICAL LEXICON.

A

BOTANICAL LEXICON,

OR

Expositor of the Terms, Facts, and Doctrines

OF THE

VEGETABLE PHYSIOLOGY,

BROUGHT DOWN TO THE PRESENT TIME.

BY

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"Scientia nihil aliud est quam veritatis imago."—BACON.

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TESTIMONY OF THE HIGH ESTIMATION,


IN WHICH

THE SERVICES HE HAS RENDERED TO THE CAUSE OF

BOTANY,

ARE HELD—BY THE AUTHOR,

PATRICK KEITH.



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It may be thought by some, that the alphabetical form of arrangement is not the best that could have been adopted for the discussion of the subjects of the Vegetable Philosophy. But if not the best, absolutely, it may be the best for a particular purpose. There is nothing, indeed, in the title of a Botanical Lexicon half so attracting as in that of a System of Botany, or of Botany for Ladies. Yet the Lexicon has its advantages in the facility which it gives to the finding of any specific article that may be wanted, without reference to system, the value of which the novice does not yet fully comprehend; and as the subject is broken down into distinct heads, many of them being very short, and no one of an extreme length, the reader can take more or fewer of them, at pleasure, according to the time he may be able to devote to a single sitting, without being under the necessity of breaking off in the middle. Thus he finds every thing in its own proper locality, expressed, at least in the present work, with as much of brevity as is compatible with perspicuity; whether it be the definition of terms; or a statement of Physiological Facts; or a condensed and circumscribed exposition of the several doctrines or hypotheses that have been, or are now, the most popular amongst Botanists; so that the reader's attention is not exposed to the risk of being fatigued by too long an article, but is, on the contrary, often relieved by a change of subject, and the reader himself induced, without his own knowledge, as it were, to proceed further, as in the case of modern novels; those being always the most eagerly devoured, as it is said, which have the shortest chapters.

It may also be thought that an article on Zoology has nothing to do in a botanical work. M. Dutrochet thought otherwise; and as his opinion is here adopted, so also is his example, by the introduction of the topic. It may not have been introduced in the best possible manner; but it is hoped enough has been said to show that the botanist who knows nothing of the Physiology of Animals, is but half qualified to elucidate, duly, the subject of the Physiology of Vegetables.

P. KEITH.



BOTANICAL LEXICON.

A, in the composition of botanical terms, is merely the alpha privative of the Greeks, and denotes negation; as aphyllous, without leaves; acotyledonous, without cotyledons.

ABBREVIATED.—Of two organs in comparison, the shorter is said to be abbreviated;—an abbreviated calyx—a calyx shorter than the corolla.

ABORTIVE.—Barren; as a flower that falls without producing fruit.

ABRUPT.—Winged leaves that have no odd leaflet or tendril are said to be abrupt, or abruptly winged.

ABSORPTION.—The process by which vegetables take up their aliment is termed absorption. But as plants are not furnished with any individual organ similar to the mouth of animals, how, after all, it may be said, is the absorption of their food effected? Is it by the general surface of the stem, leaf, or root, or by any peculiar portion of these organs? By whatever part or portion of the plant the food may enter, it must at any rate pass through the covering of the epidermis, which the earlier physiologists thought it could not do, but by means of pores more or less visible. Yet some of them described the epidermis as being of so close and compact a texture that the eye, aided even by the best microscopes, was unable to discover in it the slightest vestige whether of pores or of apertures. But Hedwig and De Candolle detected what seemed to be superficial pores in the leaves at least of many plants; and so will any one else who will be at the trouble of repeating their observations with lenses of similar powers.

The next difficulty was with regard to the epidermis of the flower, fruit, and root. No pores had been detected in the flower and fruit, though it was evident that they were refreshed and invigorated by the access of moisture and of atmospheric air; and no pores had been detected in the root, though it was evident that the whole of the nourishment which the plant derives from the soil must of necessity pass

through it. It was also evident that no aliment could be taken up by the plant, except in the state of a liquid, or of a gas; that is, by absorption, or by inhalation, as the chyle is taken up into the animal lacteals, or the air into the cells of the lungs. The avidity with which plants absorb water was perceived and acknowledged even in the earliest times, and even by men who were not botanists. Anacreon, in one of his little trifles in honour of drinking, makes the very trees of the forest drink :—

‘Η γῆ μέλαινα πίνει,
Πίνει δὲ δένδρε’ αὐτην.—Ode xix.

“The black earth drinks, and the trees drink it;” that is, the moisture which it contains.

By merely immersing in water a plant of almost any species of moss that has been some time gathered, or long exposed to drought, so as to have had its leaves shrunk or shrivelled up, the moisture will immediately begin to penetrate the plant, which will thereby resume its original verdure; an experiment establishing the fact of the entrance of moisture into the plant through the medium of the epidermis.

It might be doubted whether any of the moisture thus imbibed had passed through the root. But if the bulb of a hyacinth is placed over the mouth of a glass vessel filled with water, so as that the extremities only of the radical fibres shall be immersed, the water is imperceptibly exhausted, and the plant grows. The moisture must consequently have passed through the root. Plants seem indeed to have a peculiar facility in taking up water by the root, from the infinite number of little, absorbent, bibulous sponges (*spongiolæ*) in which the fine fibres of the root terminate. This is the grand apparatus that nature has destined to the office of the absorption of vegetable nutriment; and it is owing to the powerful absorbent property of the *spongiolæ* of which it consists, that the scientific gardener, in the transplanting of his young trees, or the scientific and ornamental planter, in the transplanting of his trees of full growth, is so extremely careful to preserve entire even the minutest fibres and extremities of the roots. Sir Henry Stewart’s *Planter’s Guide* has taught him the great importance of these little organs.

Hales instituted a variety of experiments to show the absorbing power of roots, and the force with which it acts. But as they were made chiefly on the sections of roots laid bare and immersed in water, they do not exhibit any direct illustration of the natural action of the *spongiolæ*, collecting nourishment at ten thousand different points from the moisture of the soil; and in this respect the experiments are defective. The next topic of enquiry was the absorbing power of the leaves, which Duhamel and Marriotte did much to elucidate. But

the most satisfactory set of experiments upon the subject of leaves is that of M. Bonnet of Geneva, whose main object was to ascertain whether the absorbing power of a leaf was alike on both surfaces. With this view he placed a number of leaves over water, so as that they floated on it but were not immersed; some with the upper surface, and others with the under surface applied to the water. If the leaf retained its verdure the longest with the upper surface on the water, the absorbing power of the upper surface was to be regarded as the greatest; but if it retained its verdure the longest with the under surface on the water, then the absorbing power of the under surface was to be regarded as the greatest. Some leaves were found to retain their verdure the longest when moistened by the upper surface, and some when moistened by the under surface; and some were altogether indifferent to the mode in which they were applied to the water. But the inference deducible from the whole, and deduced accordingly by Bonnet, was, that the leaves of herbs absorb moisture chiefly by the upper surface, and the leaves of trees chiefly by the under surface. What is the cause of this singular disparity between the absorbing surfaces of the leaf of the herb, and of the tree? The physical cause might be the existence of a greater or of a smaller number of pores found in the leaves of the herb and tree respectively. The chemical cause would be the peculiar degree of affinity existing between the absorbing organs and the fluid absorbed. Duhamel seems to have been content to look to the physical cause merely, regarding the lower surface of the leaf of the tree as being endowed with the greater capacity of absorbing moisture, chiefly for the purpose of catching the ascending exhalations which must necessarily come in contact with it as they rise, but which might possibly have escaped it if absorbable only by the upper surface, owing to the increased rapidity of their ascent at an increased elevation; and regarding the upper surface of the leaf of the herb as being endowed with the greater absorbing power, owing to its low stature, and to the slow ascent of exhalations near the earth. This did not throw much light upon the subject; and the experiments were still deemed insufficient, as not representing to us the actual phenomena of vegetation, though the fact of the absorption of moisture by the surface of the leaf is fully confirmed by such phenomena:

If after a long drought a fog happens to succeed before rain falls; so as to moisten the surface of the leaves, plants begin to revive, and to resume their verdure long before any moisture can have penetrated to the roots. Hence it follows incontestably, either that moisture has been absorbed by the leaf, or that transpiration had been suddenly stopped by the closing up of the pores, now STOMATA, of the leaf, or

both. The efficacy of rains themselves and of artificial waterings may be accounted for partly on the same principle, for they have not always penetrated to the root when they are found to have given freshness to the plant. The moisture, then, that enters the plant as an aliment, is taken up by means of the pores or stomata, or, in default of visible pores or stomata, merely by means of the absorbent power of the epidermis, not only of the root and leaf, but often, as it is to be believed, by the other parts of the plant also, at least when they are soft and succulent.

By what means do the gases enter the plant?—If water or other non-elastic fluids are capable of penetrating the outer bark of plants, whether furnished with visible pores or not, gases may well be supposed to be endowed with a similar capability. It might be asked, however, whether the water and the gases enter by the same pores, where pores are found to exist. But though there appears to be nothing absurd in the assertion of the affirmative, yet it seems probable that each has its own peculiar pores or stomata. At least, it is known that some surfaces which repel moisture exhibit no evidence leading us to suppose that they repel the common air. This is well exemplified in the case of cabbage-leaves, in the time of rains and dews, when the drops roll along the upper surface of the leaf without wetting it, or lodge in its folds like globules of quicksilver. So also in the case of fruits covered with bloom. It is probable, therefore, that all such leaves and vegetable surfaces as repel moisture are fitted rather for the inhalation of air, which they have long been regarded as capable of effecting; and in times in which it was fashionable to look for analogies between the plant and animal, in every thing whatever, leaves were even regarded as being the lungs of plants. Grew thought he had discovered in the leaves a number of little bags or bladders filled with air. The air was supposed to have entered by inhalation, and the bags or bladders were supposed to be analogous in their function to the cells of the lungs of animals. M. Papin introduced into the receiver of an air-pump an entire plant, root, stem, and leaf; but the consequence was that it very soon died. He then introduced a plant by the root and stem only, the leaves being still exposed to the influence of the air. The plant lived for a considerable length of time, and hence he concluded that leaves are lungs. But these facts are far from being sufficient to settle the point in question, and we introduce them, not so much with a view to show their inadequacy, as to show that the doctrine, even if founded in truth, could not have been satisfactorily demonstrated by any experiments that were practicable at that time.

It is to the modern improvements in pneumatic chemistry (and to

them alone) that we are indebted for our knowledge of the real functions of the leaves of plants, and of their analogical resemblance to the lungs of animals; it being now proved indisputably that the leaves of plants not only contain air, but do both inhale and respire it. It was the opinion of Priestley that they inhale it chiefly by their upper surface; and it has been shown by Saussure that their inhaling power depends entirely upon the integrity of their organization. A bough of *Cactus Opuntia* detached from the plant and placed in an atmosphere of common air, inhaled in the course of a night four cubic inches of oxygen; but when placed in a similar atmosphere, after being cut to pieces and pounded in a mortar, no inhalation took place.

Yet it may be said that the doctrine of vegetable respiration is still involved in something of mystery, as the existence of pores is doubted by botanists of high reputation, even in what are called *Stomata*; and as the occurrence of *Stomata* is but a very rare phenomenon in the epidermis of roots, flowers, or fleshy fruits, or bulbs, which, after all, will not thrive or ripen well, if wholly deprived of air. But the recent experiments of M. Dutrochet have shown that the intervention of visible pores is not at all necessary, whether to the imbibition of moisture, or to the inhalation of gases, or whether in the case of animal or of vegetable membrane. The liquid, or the gas, seems thus to enter by means of the agency of organic molecular infiltration, a power prodigious in its capabilities, but not easily accounted for. Dutrochet attributes it to what he calls *endosmose*, that is, a rush inwards of a less dense to a more dense fluid, excited by electricity. His experiments and hypothesis will be specified and examined under the article of the ASCENT OF THE SAP, or its CAUSE. In the mean time we will content ourselves with merely saying that we do by no means regard his conclusions as following legitimately from his premises; nor can we regard any cause accounting for the effect in question as being at all adequate to its object, which does not involve the agency of a power of a higher order than that either of capillary attraction or of electricity; namely, that of the agency of the living energies of the plant.

ACEROSE.—Linear and needle-shaped, as in the leaves of cone-bearing trees.

ACETIC ACID.—A native vegetable acid, volatile, colourless, pungent; the *acetum* of the ancients (*acre potet acetum*—Hor. Sat.), the vinegar of the moderns—that is, as dissolved in a certain portion of water. It was found by Vauquelin in the sap of several trees, and by Scheele in that of *Sambucus nigra*. It is generally manufactured from wine in a certain stage of fermentation, or from the distillation

of wood. Its composition in a state of purity is not yet thoroughly determined by chemists. According to some it contains about two or three parts in the hundred of oxygen; according to others it contains none at all, and is merely a compound of water and carbon. If this last is the fact, then acidification and oxygenation are different things. But M. Raspail, after G. Lussac and Thenard, gives its composition as follows:—carbon, 50.224; oxygen, 44.147; hydrogen, 5.629.

ACIDS.—Acids are a class of substances distinguishable by the following properties:—They redden vegetable blues; they form salts with alkaline bases; and they excite in the palate the sensation of sourness. A brief account of the principal acids peculiar to vegetables will be given under the terms by which they are respectively designated. They are composed for the most part of oxygen, united, in a greater or in a less proportion, to a double base of carbon and of hydrogen; though some of them are regarded as being composed merely of carbon and azote, upon the presumption that oxygen is not the sole cause of acidity, which the discovery of chlorine has confirmed.

ACINI.—The distinct granulations of which the fruits called berries are composed.

ACCLIMATATION.—This term De Candolle introduces into his *Physiologie Végétale*, as implying the act or operation of accustoming plants to bear a temperature or climate different from that to which they are indigenous. He is at great pains to point out to the reader the line of boundary by which it is to be distinguished from naturalization, but we do not think that he has been very successful.

ACOTYLEDONOUS PLANTS.—Of the grand and primary divisions which botanists have introduced into their systems, one of the most celebrated is that by which the subjects of their arrangements are distributed into cotyledonous plants on the one hand, and acotyledonous plants on the other. Cotyledonous plants are peculiarly characterized by the presence of what are called seed lobes in the fruit or seed; while acotyledonous plants are characterized by the absence of seed lobes in the fruit or seed.

The former group corresponds to the phœnogamous plants of modern botanists, consisting of from 38,000 to 40,000 species, and as divided into monocotyledonous, dicotyledonous, and perhaps polycotyledonous sections, according to the number of cotyledons proper to the species. This division has acquired its celebrity chiefly in consequence of its having been selected by Jussieu as the basis of his natural system, which has been prevailing and will continue to prevail, over all artificial systems whatever, not excepting even that of

the great Linnæus ; because, being founded in nature, it rests upon a rock that cannot be shaken.

The latter group corresponds pretty nearly in its extent to the cryptogamous plants of Linnæus, or the agamous plants of Humboldt, amounting as it is said to about 8000 or 10,000 species—[Burnett's Outlines.] Hence it will be seen that it embraces merely the lower grades of the vegetable creation—the Filices, the Musci, the Hepaticæ, the Algæ, and the Fungi ; being placed as it were at the bottom of the scale, and exhibiting in the outward aspect, as well as in the internal structure, nothing of that loveliness of form, and but rarely that brilliancy of colouring—nothing of that complicated workmanship by which the higher grades of vegetables are distinguished. They are the first and simplest forms of vegetable life, many of them consisting merely of a cluster of minute cells or of minute threads, as in the case of *Protococcus* and *Byssus* ; and many of them being, in fact, nothing more than a mere slime or mucor, as in the case of the *moulds* and *nostocs*. Yet these minute, neglected, and apparently insignificant vegetables are by no means useless or superfluous in the scale of nature. They serve to complete and to keep up the integrity of the vegetable creation, whether it be by decomposing putrid and fecal matters, or by preparing a soil fit for vegetables of a higher order. They are scattered over all climates and all quarters of the world, replenishing both earth and sea with vegetable life, and ascending even into the regions of the air by the very levity of their seeds, spores, or bulbules, to be wafted on the winds, till, drenched with moisture, they descend again towards the earth, ready to cling to the soil that suits them, if it should be even the surface of the flinty rock, or to spread themselves over mountains of eternal snow, or to immerse themselves in the waters of the ocean. Thus many of the Algæ, at least, sow their seeds and thrive where no other plant would live. They grow up, come to maturity, and perish where they grow, forming, in process of years, a soil of some depth. First mosses, and then ferns, are found to follow in their train, leaving a soil deeper and richer still, till at last, in the revolution of ages, the very surface of the barren rock is covered with a soil capable of supporting the loftiest trees.

AERIAL ROOTS.—Some roots may be said to be aerial, inasmuch as they issue from the stem at different degrees of altitude, and thence elongate in a descending direction till they reach the soil, into which they insinuate their extremities. This process is well exemplified in *Pandanus odoratissimus*. The device of nature is to give stability to the plant, for the stem being arborescent, and widening as it ascends, though of but small diameter at the base, and thus not readily

admitting the internal descent of such root fibres as originate in the upper and wider part of it, would invariably perish if it were not that the root buds are enabled to force their way to the exterior, and so to descend till they reach the soil, to which they firmly rivet the plant, and out of which they draw the necessary supplies.—[Burnett's Outlines, 1106.]

The above is the law of the developement of the species in the case in question. But there are plants which, though not regularly protruding aerial roots, have been found to do so in cases of necessity. At New Abbey in Gallowayshire, in the year 1817, there was growing on the top of a stone wall, which measured ten feet in height, a plane tree, which measured twenty feet in height. On this bare and scanty soil it could not originally have found much nourishment, and could not send down its roots through stone and mortar. Accordingly it had been compelled many years before to protrude them into the open air. They elongated by descent, clinging to the side of the wall, and throwing out neither bud nor branch till they reached the ground, which they did after a period of several years. Here, having plunged their extremities into the soil, they found and transmitted the necessary nourishment, and the tree grew with vigour.—[Phil. Mag. vol. xlix.]

ÆSTIVATION.—A term employed by botanists to denote the manner of the folding up of the parts of the flower, whether sepals, petals, or stamens, previous to their evolution in the process of vegetation. It is to the flower what vernalion is to the leaf, and its varieties of mode will be found under the article BUD.

AFFINITY.—Vegetable affinity is that natural relation or connexion by which plants having the same form and structure of parts are regarded as belonging to the same tribe, or class, or genus.

AGE OF PLANTS.—The age or duration of the life of vegetables is considerably diversified in different tribes. Some have their age bounded by the term of a single year or season, and are hence called annuals; as poppies, balsams. Some have it extended to a period of two years, and are hence called biennials, as the carrot. Others live to an indefinite period, and are hence called perennials; of which tribe some particular species are most singularly long-lived. A few of the most extraordinary examples of protracted vegetable existence will be introduced under the head of the article LONGEVITY OF PLANTS.

AGGREGATE FLOWER.—A flower composed of a number of minute florets, or floscules, contained within a common calyx, or inserted in a common receptacle, with the florets on peduncles, but the anthers not united, is an aggregate flower; as in *Dipsacus* or *Scabiosa*.

AIR.—The air of the atmosphere is indispensable to vegetation in all its stages; and a plentiful supply of it is indispensable to vigorous growth. Seeds will not germinate in a perfect vacuum, as was experimentally shown long ago by Ray; nor will plants continue to vegetate if placed in vacuo, as was proved by the experiments of Marriotte. It is not even enough that the air has access merely to those parts of the plant which spring up above ground. It must have access, likewise, to the roots, for plants will not thrive if the root is buried too deep in the earth; and hence it is that roots in general do not penetrate to a great depth, but rather creep along horizontally near the surface, and within reach of the access of air, which enters the spongiolæ in solution with the moisture of the soil. The *rationale* of the action of air upon plants, and of plants upon air, we reserve for introduction under the head of the articles, GERMINATION, FUNCTIONS OF LEAVES, or ELABORATION OF GASES.

AIR CELLS.—The openings which occur in the interior of the plants, whether regularly and symmetrically, or accidentally, and without order, botanists, particularly Link and Kiesser, designate by the appellation of lacunæ or air cells. Yet we think the appellation is not very happily chosen. For while it holds out the idea of cells similar to those of the cellular tissue, it includes, at the same time, gaps, spaces, cavities, of all shapes and of all dimensions, some of them being actually tubular, as in the hollow stems of the garlicks, and of the grasses, and of many of the aquatics. In *Equisetum* they assume a regularity of disposition that is peculiarly remarkable,—one gap larger than the rest occupies the centre of the stem, around which a number of smaller gaps are placed in a circular row, which is again encircled with a second row of gaps larger than the last, and alternating with them, and forming, in the aggregate, a sort of symmetrical group. Now these cavities are not well designated by the appellation of air cells, but where spaces, containing air, and communicating with the *stomata*, occur in the parenchyma of the leaves, as we learn from the observations of M. Ad. Brongniart that they often do occur, as in the case of floating leaves, *there* the appellation of air cells may, perhaps, be sufficiently appropriate.

AIR VESSELS.—As air was known to be indispensable to the life of vegetables, it seemed to the earlier physiologists to be but reasonable to suppose that it was inhaled into their substance in some way analogous to that by which it is inhaled into the lungs of animals, and conveyed in appropriate vessels to their several parts. What were the vessels conveying it? Grew thought he had discovered them in his detection of the spiral tubes. The spires bore a slight resemblance to the rings of the *tracheæ* of animals, and were pre-

sumed to be organs destined to similar functions. But this opinion has not been generally adopted by succeeding physiologists; and was, as we believe, finally abandoned even by Grew himself. Hence we have been somewhat surprised to find in the work of an eminent physiologist of the present day, not merely a revival of Grew's first opinion with regard to the function of the spiral tubes, but an extension of it to all other vessels whatever that may be found in plants. Hitherto physiologists have regarded them as being vessels conveying sap; now, M. De Candolle (Phys. Veget. i. 86.) regards them as being vessels conveying air, the intercellular passages being the main channel of the sap's ascent. Upon this novel and somewhat startling doctrine we purpose to offer some remarks under the head of the article **VESSELS OF PLANTS, or their FUNCTIONS.**

ALBUMEN.—The term albumen, as applicable to vegetables, has an acceptation both anatomical and chemical; for in its anatomical acceptation it signifies an organ which constitutes the bulk or *farina* of many seeds, as in the Grasses, and often invests the embryo entirely, as in the Palms and Lilies; but in some tribes, as in the Leguminosæ, it is altogether wanting. [See **DISSECTION OF SEEDS.**] In its chemical acceptation it signifies a substance which is obtained from vegetable gluten when treated with alcohol. Part of the mass is soluble, and takes the name of *Zimôme*, the principle of leaven (Taddei), or retains that of gluten (Berzelius), and part of it is insoluble, and takes the name of Gliadine (Taddei), or of vegetable albumen (Berzelius). Hence gluten seems to be a compound of two substances as yet imperfectly known. [Raspail, Chem. Organ. 140.]

ALBURNUM.—The alburnum is the outermost and last-formed layer of the woody portion of the caudex of exogenous plants. It is the softest and whitest of all the layers except, as they say, in the Eagle-tree, *Aquilaria Malaccensis*, in which it is black. It owes its formation to the descent of the cambium, or elaborated sap, which is deposited as it descends between the bark and alburnum of the former year. In the following year it is the chief channel of the sap's ascent, for which, from its soft and succulent texture, it seems to be well adapted. But it remains in the state of alburnum only so long as it is the outer layer, the new layer that is formed above it taking the name of alburnum in its turn, while the old alburnum, being now an inner layer, and no longer the main channel of the vegetable juices, grows gradually harder and denser, and of a duller and deeper shade each succeeding year, till at last it is converted into what is called the *duramen* or heart-wood of the plant.

ALCALOIDES, ALCALOIDS.—The alcaloides (alcaloids) are a class of vegetable substances that manifest alkaline properties only in a slight

degree. They have not been very long known to chemists; the discovery, which is due to Sertuerner, having been made about the year 1816. They are composed of the three leading principles of vegetable bodies, with the addition of a portion of azote, from which, it is presumed, they derive their alkalinity. They are obtained by precipitation from a watery solution of vegetable matters. Some assume the form of crystals; others that of a powder; and all of them form salts with acids. The names by which they are designated take the termination of *ine* among French chemists; whence the long list of substances of this family—quinine, iodine, veratrine, strychnine; but with British chemists they take the termination of *ia*. Specific details of some of the most important of them will be given in their proper places.

ALCOHOL.—Alcohol, or ardent spirit, is obtained from the distillation of wine, beer, cider, and various other liquors the product of fermentation. In its state of purity it is perfectly limpid, and takes the appellation of spirits of wine. It is considerably lighter than water, with which it combines. It is the best solvent of resins and essential oils, and is often employed as a chemical test. According to Saussure it is composed of 51.98 carbon, 34.32 oxygen, and 13.70 hydrogen. It is produced spontaneously in the organs of plants as often as the sugar and the gluten which they contain come into contact. Hence certain fruits exhale an alcoholic odour when cut with the knife. [Raspail; Chem. Organ. 485.]

ALGÆ, or FLAGS.—The term *algæ*, which is of Latin origin, and which we translate *flags*, seems primarily to have denoted any sort of plant or herb growing in sea-water.

“Cras foliis nemus
Multis, et *alga* littus *inutili*
Demissa tempestas ab Euro
Sternet.”—HOR. Lib. iii. Ode 17.

Yet botanists have extended its application to many plants that are not even aquatics; agreeing, however, in the common character of having their herbage frondose, and their frond for the most part without a distinct root.

Where a root exists it is merely a fibrous or scutate base, for the purpose, not of nourishment, but of attachment, as in the *Fuci*. The frond is not uniform in its appearance throughout the several divisions of the order. In the Tremellinæ it is gelatinous, as in *Palmella nivalis*, the substance that gives colour to the polar snows; in the Confervoideæ it is jointed and filamentose; in the Fuci it is coriaceous or leather-like; and in the Lichens, which do not well associate with the

rest of the Algæ, it is powdery, crustaceous, gelatinous, or even shrub-like.

The fructification of the Algæ is less perfectly known than that of any of the other orders of the cryptogamia; and yet it has received, like them, considerable elucidation from the labours of late investigators. Dr. Hooker describes it as consisting merely of seeds or spores in tubercles, or in processes issuing from the frond, or immersed, or more or less scattered on the surface. In the Lichens there issues from the edge of the frond a number of small warts or tubercles, of the colour and contexture of the general herbage, and containing a multitude of small granules, which Hedwig regarded as particles of pollen. From a different part of the frond there issues also a number of cup-shaped or target-shaped substances, containing multitudes of small and minute granules, which he regarded as seeds. Several of the Fuci are edible, and much relished by many people whether raw or dressed. The *Lichen pulmonarius* is employed in medicine, and the *Lichen parellus* in the art of dyeing.

ALKALIES.—Alkalies are a class of substances distinguishable by their caustic taste and property of changing vegetable blues into green. They are three in number—ammonia, potass, soda. The first, ammonia, was not formerly classed among vegetable substances, being obtainable chiefly from *sal ammoniac* or from animal matters. But though it is not found in any great abundance in the vegetable kingdom, yet it is not unfrequently to be met with, at least in small quantities. De Candolle represents it as occurring in a free state in the leaves of *Isatis tinctoria*, and in *Fucus vesiculosus*, as well as combined with other matters in the root of Black Hellebore, and in the leaves of *Aconitum Napellus*, as also in the spontaneous decomposition of vegetables, though in this case there is reason to suspect that it is merely a product resulting from the process that is going on. It takes the name of the volatile alkali. The two other alkalies, potass and soda, were classed among vegetable productions, as being obtainable chiefly from plants: potass from the ashes of wood burnt in the open air and subjected to the process of lixiviation, and soda from the ashes of marine plants treated in the same way. After all it is a matter of doubt whether they are of vegetable origin or not. They take the name of the fixed alkalies.

From the earliest times these two alkalies were regarded by chemists as simple substances, till the period of the notable discovery of Sir H. Davy, who had the enviable felicity of being the first to decompose them, and to make known their component parts. Potass consists of a highly inflammable metal, potassium, and of oxygen, one proportion

of each. Soda consists of a metal, sodium, and of two proportions of oxygen. [Agri. Chem. Sec. i.] By analogy ammonia ought to consist of a metal to be called ammonium, and hydrogen; but by analysis it yields merely azote and hydrogen; of the former 81.5, of the latter 18.5. [Dec. Phys. Veg. i. 338.]

ALPINE.—Plants whose stations are the summits of lofty mountains are said to be Alpine.

ALTITUDE.—Altitude or elevation above the level of the sea is equivalent, on the score of climate, to a receding whether north or south from the line of the equator, 600 feet of altitude being thought to be equal to a degree. Hence it follows that all varieties of climate, and consequently all varieties of vegetable habitation, may exist even in the same latitude merely by means of a variety of altitude. This was found by Tournefort to be literally the fact in his travels in Asia. [Voyage du Levant.] At the foot of Mount Ararat he met with plants peculiar to Armenia; above these he met with plants which are found also in France; at a still greater height, he found himself surrounded with such as grow in Sweden; and at the summit, with such as vegetate in the polar regions. Baron Humboldt, in his personal narrative, gives us a similar account of the several zones of vegetation existing in a height of 3730 yards on the ascent of Mount Teneriffe. The first zone is the region of vines, extending from the shores of the ocean to a height of from 400 to 600 yards, well cultivated and producing date-trees, plantains, olives, vines, wheat. The second zone is the region of laurels, extending from about 600 to 1800 yards, and producing many plants with showy flowers, with moss and grass beneath. The third zone is the region of pines, commencing 1920 yards, and having a breadth of 850 yards. The fourth zone is the region of Retama, or broom, growing to a height of from nine to ten feet, and fed on by wild goats. The last zone is the region of grasses, scantily covering the heaps of lava, with cryptogamic plants intermixed, and the summit of the mountain bare.

This accounts for the great variety of plants which is often found in a district of no great extent; and it may be laid down as a botanical axiom, that the more diversified the surface of any country is, the richer will its Flora be, at least in the same latitudes. It accounts also for the want of correspondence between plants of different countries though placed in the same latitudes, because the mountains, or ridges of mountains, which may be found in the one country and not in the other, will produce the greatest possible difference in the character of its genera or species. To this cause, also, we may ascribe the diversity that often actually exists between plants growing in the same country, and in the same latitudes; as between those of the north-

west and north-east coasts of North America, as also of the south-west and south-east coasts; the former being, in both cases, the more mountainous, and the latter the more flat. Sometimes the same sort of difference takes place between the plants of an island, and those of the neighbouring continent; that is, if the one is flat and the other mountainous; but if they are alike in their geographical delineation, they are generally alike in their vegetable productions.

AMMONIAC.—A gum-resin thought to be the produce of a species of *Ferula*. It is brought from Africa in the shape of small tears, of a yellow colour and nauseous taste, and is used in medicine.

AMNIOS.—The amnios is a clear and transparent fluid, the product of fecundation, appearing, at first, in the form of a small drop or globe, and occupying the centre of the vegetable ovulum. In some cases it has no peculiar cuticle; but in others it is invested with a fine and filmy membrane,—the quintine of Mirbel,—the embryonic sac of Brown.

ANALOGY.—The relation of analogy is said to consist in a correspondence between certain parts of two individuals, or two groups of individuals differing in general structure, and belonging to different series, as in the case of the primary groups of Acrita and Proto-phyta; while the relation of affinity is said to consist in the correspondence of individual structures of the same group or series, as in the case of the several species of which Acrita and Proto-phyta are respectively composed. These distinctions have been learnedly illustrated by Mr. McLeay, in his *Horæ Entomologicæ*, as well as by some of the continental writers, and magnified into matters of immense importance. But on this subject Doctors differ. Dr. Lindley says, “the distinctions do not seem to him to possess the value that is attached to them, as cases must be continually occurring in which the terms are convertible: thus the genera *Berberis* and *Bocagea* are in analogy if considered with reference to *Berberideæ*, and *Annonaceæ*, but in affinity if viewed as a part of *Thalamifloræ*.” [Intro. 361.]

ANATOMY OF PLANTS.—The opening up of the animal fabric by section is the anatomy of animals, from *ἀνατέμνω*, to cut up, and the opening up of the vegetable fabric by section is the anatomy of plants. It is a process indispensable to the elucidation of the phenomena of life, and is the only sure foundation of the science of physiology, for we cannot attain to the *rationale* of the function of any particular organ, whether animal or vegetable, without a correct knowledge of the mechanical structure of the parts of which its fabric is composed. Hence every physiologist is by implication an anatomist, who is presumed to have made himself well acquainted with the organs in question; viewing them in all their bearings, and in all the intricacy of

their composition, and leaving nothing untouched that relates to use or to structure;—a study, as will readily be admitted, of great difficulty, and of great labour. Yet the physiologist who would confine his investigations to the anatomy of animals merely, or to the anatomy of vegetables merely, will find himself in the end to be but half qualified for the accomplishment of the task which he has in view. The student who would learn, or the writer who would elucidate, the structure and living phenomena of the animal kingdom, will find one of his best means of success to be the making of himself well acquainted with the structure and living phenomena of the vegetable kingdom also. Life in all its aspects should be made the object of his study, that the several grades of vital entity may be so placed as to throw a mutual light on one another. But what says Dutrochet?—"It too often happens that zoologists know nothing of botany, and botanists nothing of zoology." [Obs. sur les Mouv. de la Sensitive, Sect. V.]

It must be admitted, indeed, that many botanists have known but little of the anatomy of vegetables; because, resting satisfied with a knowledge of such external characters as led them through a method to the name of their plant, they cared for nothing more—a mode of study which was but too common among the botanists of ancient times. For in the botanical writings, whether of the earlier Greeks or Romans, we find nothing that can be fairly set down to the score of vegetable anatomy; and even among the moderns, botanists had made many advances towards the introduction of legitimate arrangement and legitimate definition long before the anatomy of plants formed any part of their study. But at last, and as if to make amends for former neglect, two eminent physiologists, of two different and distant countries, and without any communication with one another, happened to direct their notice to the anatomy of plants about the same period of time—that is, about the middle of the seventeenth century. These physiologists were Grew and Malpighi, the former an English, the latter an Italian, physician. It was a consequence, as we may believe, of the grand *stimulus* that had been communicated to the energies of the human mind through the event of the revival of learning, and of the introduction of a better and more logical method of philosophising, recommended and exemplified in the writings of Bacon. Thus was the study of plants first placed on its true and legitimate basis—the analysis of the vegetable subject; which has been shown to be as essential to the phytologist as the anatomy of animals to the physician. The discoveries of Grew were embodied in his *Anatomy of Plants*, published in 1682; and those of Malpighi in his *Opera Omnia*, published in 1687, together with figures illustrative of the several parts or organs of the plant, which, for truth and accuracy of delineation, may

well vie with the productions of more modern times. Grew was, perhaps, more minute in his analysis, and Malpighi in his comparative view of the animal and vegetable kingdom. No organ has escaped the ordeal of their keen research, and in assigning to the several organs their respective functions, they are often successful. Physiologists of all countries have followed in their steps, more immediately or more remotely, and those of the present day are still progressing in the same route, and exploring the recesses of vegetable organization.

The following are a few of the most distinguished observers who have hitherto advanced, or are still labouring to advance, our knowledge of the vegetable anatomy. In Italy, Corti, Comparetti, Spallanzani, Amici; in France, Duhamel, Desfontaines, Daubenton, De Candolle, Mirbel, Du Petit Thouars, Dutrochet, Adolphe Brongniart; in Germany, Gærtner, unrivalled in the department of seeds, with Hedwig, Sprengel, Rudolphi, Kiesser, Treviranus, Bischoff; and in England, Knight, Bauer, Brown, with others of minor celebrity. Yet all of these investigators have not, like Grew and Malpighi, extended their researches to the whole of the vegetable organs; but each of them has taken up and illustrated some particular organ, or apparatus at least, and thus, by means of the division of labour, shed a light upon the subject that might have been otherwise unattainable, and elevated to a conspicuous degree of eminence the vegetable anatomy of the present day. The several parts and organs of the plant, as discoverable by dissection, will be introduced into their respective places according to their alphabetical order.

ANIME'.—A resin resembling copal, but more readily soluble in alcohol. It is said to be obtained from the *Hymenæa Courbaril*, a native of the West Indies.

ANOMALIES OF VEGETABLE DEVELOPEMENT.—In the growth of the vegetable, as well as in that of the animal, there is a notable uniformity of structure in all subjects belonging to the same natural tribe or genus. But it often happens that a deviation from the general laws of developement is occasioned by the intervention of some accidental cause, or of some cause operating permanently in certain species. Hence the anomaly may regard the developement even of an individual, or of a species, and may occur either in the root, stem, branch, leaf, bud, flower, or fruit, according to the cause by which it is occasioned. The chief anomalies of developement to which vegetables are thus liable, will be introduced under the head of the several organs in which they are found.

ANNUALS.—Annuals are a class of plants that agree in the following peculiarities:—They spring from seed, grow up and produce seed, and then decay and die, all in the course of a single year or season

—*annus*. They have thus but one stage, [as it were, in the whole process of their developement, and, having finished that, their race is run. In this respect they resemble certain tribes of animals that spring from eggs, grow up to maturity, undergo, perhaps, various transformations, and propagate their kind and die—all in the course of a single summer,—but some in the course even of a single day. Some plants which are annuals in a cold climate, such as that of Sweden, will become perennials if transported to a hot climate, such as that of the West Indies. This anomaly is said to have been exemplified in *Tropæolum* and *Beta*. Many annuals are remarkable for their beauty of colouring, or fragrance of perfume; such as the Stocks, the Amaranths, the Balsams; whence they have been long the object of the care of the florist, and the delight of the fancier of flowers.

ANNULUS.—The annulus or ring is a term applied to designate a peculiar organ connected with the fructification of certain tribes of plants;—namely, Ferns, Mosses, Fungi; though it is neither of the same form in all of them, nor destined to the same function. It will be noticed specifically under the head of the several tribes to which it belongs.

ANTHER.—The anther, from *ἀνθηρός*, flowery, is an organ belonging to the flower; being a small bag or viscus attached to the filament, and containing a fine powder. Its attachment is usually terminal, as in the Tulip, but sometimes it is lateral, as in Herb Paris. If the filament is altogether wanting, it is then placed immediately on the ovary or pistil, and is said to be sitting. A single filament has generally a single anther; but the filaments of *Mercurialis* have two, of *Fumaria* three, and of *Theobroma* five anthers. If they are so situated as to incline or approach to each other, they are said to be convergent, as in *Cyclamen*; and if they grow together so as to form a tube, as in the florets of the Dandelion, they are said to be syngenesious. Their figure is linear, or oblong, or globular, or oval, or kidney-shaped, as in Foxglove, or arrow-shaped, as in *Crocus*. Their surface is smooth, as in the grasses, or downy, as in *Acanthus*. Their structure is one-celled, as in Mercury, or two-celled, as in *Ophrys*, or four-celled, as in *Tetralthea*; the several cells being united by means of a proper organ called the *connectivum*. When the anther comes to maturity the cells burst by means of a natural fissure, and the contained powder explodes. The direction of the fissure is generally vertical, or in a line from the base to the summit of the anther; and its aspect is either towards the pistil, that is *introrse*, or towards the petals, that is *extrorse*. The discharged powder is by botanists denominated the *pollen*, of which a detailed account will be given under the head of that article.

APHRODITES.—Plants which have perceptible female organs, but no perceptible male organs, with a seed that is seemingly nothing more than a mere embryo, are called aphrodites, or at least they *were* so called by Gærtner, who exemplified them in the *Filices*, *Musci*, *Fuci*.

APOPHYSIS.—A globular bunch or protuberance in which the pedicle of some of the Mosses terminates, and on which the capsule sits, as in the genus *Splachnum*.

AQUATICS.—Aquatics, or plants growing in water, are distributed into several tribes or classes according to the peculiar habitats which they specifically affect, or to the degree of immersion which they require.

The grand and leading class is that of marine plants, *Marinæ*, such as the Fuci, Ulvæ, and many of the Confervæ. Of the Fuci some affect the very depths and recesses of the ocean. At the depth of 205 feet the lead, as we learn from the personal narrative of Humboldt, brought up sea-weed green as grass. From the same narrative we learn that the floating meadows of Fuci met with in the middle of the Atlantic, and first seen by Columbus, are not at the same time fixed to the bottom, though the stem of *Laminaria Pyrifera* has been occasionally found to measure not less than 850 feet in length. In their origin they have, no doubt, been attached to rocks of unfathomable depths, but in process of time they are swept off by the under-currents, and elevated to the surface.—Others of the Fuci affect, not the depths, but the shallows of the sea, attaching themselves to stones and to rocks that are generally laid bare at low water. Such species are immersed in the wave, as the tide of flood advances, and again left exposed to the action of the atmosphere as the tide of flood retreats. They are very common on the shores of Great Britain, and are known by the name of sea-thong, sea-tangs, or sea-wrack, including Dulse and Laver, which many people are fond of eating. From the Fuci, that is from certain species of Fuci, the inhabitants of the sea-coast obtain their kelp, well known for its utility in the manufacture of glass, and the chemist his *Iodine*, that now begins to enter into our medical recipes, to swell the pages of our pharmacopœias.

A second class of aquatics is that of river plants, *Fluviales*, such as the Chareaceæ, and many of the Confervoideæ, particularly the Oscillatoria, noted for their quick growth and singular movements approaching to animality; together with some of the Ranunculaceæ, and Potamogetons.

A third class of Aquatics is that of paludal, or fen plants, *Paludosæ*; that is, such as are peculiar to lakes, marshy and stagnant or nearly stagnant waters, but of which the bottom is tolerably clear. In such stations you find *Isoetes lacustris*, *Butomus umbellatus*,

with many of the Ranunculaceæ, and Nympheaceæ, some of them being wholly immersed, and others only in part.

ARIL.—The aril, *arillus*, is a coat formed by an expansion of the umbilical cord, and proper to an individual seed, which it invests as an appendage, either wholly or in part, though not adhering to it closely except by the base, and detaching itself at last spontaneously. It is elegantly exemplified in the outer and orange-coloured coat of the seed of *Evonymus Europæus*, that presents itself so conspicuously to the eye when the valves of the capsule have opened. In this case it invests the seed wholly, and is hence said to be complete; but in others, as in *Celastrus*, it invests the seed only in part, and is hence said to be dimideate. It is usually of a membranaceous or leathery sort of texture; but in *Evonymus* it is somewhat succulent, and in a few species of *Orchis* it is said to resemble a finely reticulated web, if this web is really an aril. In *Oxalis*, it is membranaceous and elastic, ejecting the ripe seed with considerable force. The mace which envelopes the shell or internal pericarp of the nutmeg is generally regarded by botanists as an aril; and this view of the subject seems to be sufficiently correct; because the organ in question, though not enclosed within the shell, is yet enclosed within the external pericarp or ovary, and has its origin in the umbilical cord. The envelope of the seed of the *Carex* has been by some botanists transferred to the head of the aril also, and yet in this case the propriety of the transference may be doubted, because the organ in question includes not merely the seed, but also the ovary itself; and if not, the seed is without an ovary.

ARMATURE.—Many plants are furnished with special organs that seem destined as a defence to protect them from the attack of animals,—as thorns, prickles, spines, stings. Such organs have been called their armature. See these articles.

AROMA.—The aroma of plants is that volatile part of their substance from which they derive their odour. It is cognizable by the sense of smell only; and is perhaps merely the more evaporable part of their essential oil, disengaging itself from its combinations.

ASCENT ON THE PLUMELET.—In the process of the developement of the parts of the seed, the radicle, as it elongates, uniformly descends into the soil, while the plumelet uniformly ascends into the air; and if you even invert their position, they will resume their original direction. The opinions of physiologists concerning the cause of this curious phenomenon will be introduced at the article GERMINATION, or DIRECTION OF THE RADICLE AND PLUMELET.

ASCENT OF THE SAP.—We have seen already, at the article ABSORPTION, that the moisture of the soil enters by the *chevelure* of the root,

which is composed of an infinite number of little rootlets terminating ultimately in a multiplicity of club-shaped substances, which, from their soft and bibulous texture, have been called *spongiolæ* or little sponges. These are the absorbing organs. But the fluids existing in the soil when absorbed by the root are designated by the appellation of sap or lymph, which, before it can be rendered subservient to the purposes of vegetable nutrition, must either be immediately distributed throughout the whole body of the plant, or intermediately conveyed to some organ or viscus proper to give it elaboration.

A very simple experiment will be sufficient to show that the sap is in motion, in one direction or other, at least at occasional periods. If the branch or trunk, or even root, of a tree is laid open, in the course of the spring, whether by section or by fracture, whether intentionally or by accident, the sap will immediately begin to flow from the wound, and will in some cases continue to flow copiously, perhaps for several days. Open up the wound again, and the sap will flow afresh. This is what is usually denominated the bleeding of plants, and is well exemplified in the Vine, Birch, Maple, and Walnut, as affording a most copious discharge. Yet this bleeding or depletion of the vegetable subject does not seem to injure the individual in any material degree. Vines which Duhamel subjected in the trimming to a very copious discharge of sap, grew as vigorously and yielded fruit as plentifully as others which were trimmed in the usual way.

The plant always bleeds most freely about the time of the opening of the bud; for in proportion as the leaves expand the sap flows less copiously, and when they are fully expanded it entirely ceases. Are we to conclude, therefore, that the motion of the sap is at other seasons wholly suspended, or that it only flows with diminished velocity? It has been the opinion of some phytologists that the motion of the sap is wholly suspended at least during the winter. But the opinion is erroneous. Many plants may be made to bleed in autumn, and Palms, as it is said, may be made to bleed at any season of the year. Besides, if the colds of winter should prevent the plant from bleeding, it does not necessarily follow that they prevent the sap from flowing. Buds exhibit a gradual developement of parts throughout the whole of the winter, as may be seen by dissecting them at different periods. So also do roots. Evergreens retain their leaves, and many of them, together with the beautiful family of the Mosses, protrude even their blossoms, in the very midst of December's snow.

The sap then is in perpetual motion, with a more accelerated or with a more diminished velocity, throughout the whole of the year; but, still there is no decided evidence exhibited in the mere circumstance of the plant's bleeding, to indicate the direction in which the sap is

moving at the time ; for the result might be the same whether it was passing from the root to the branches, or from the branches to the root.

The following experiment dispels the doubt.—If the bore or incision that has been made in the trunk is minutely inspected while the plant yet bleeds, the sap will be found to issue almost wholly from the inferior side. If several bores are made in the same trunk, one above another, the sap will begin to flow first from the lower bore, and then from those above it. If a branch of a vine be lopped, the sap will issue copiously from the section terminating the stem, but not from the section terminating the part that has been lopped off. This proves indubitably that the direction of the sap's motion, during the season of the plant's bleeding, is that of ascent;—and its very velocity has been made the subject of calculation. To the stem of a vine cut off about two feet and a half from the ground, Hales fixed a mercurial gauge which he luted with mastich. The gauge was in the form of a syphon, so contrived that the mercury might be made to rise in proportion to the pressure of the ascending sap. The mercury rose accordingly, and reached as its maximum to a height of thirty-eight inches. [Veg. Stat. Exper. 36.] But this was equivalent to a column of water of the height of forty-three feet three inches and a half, demonstrating a force in the motion of the sap that, without the evidence of experiment, would have seemed altogether incredible.—What is the channel through which the sap ascends; and what is the cause by which it is impelled?—For an answer to these inquiries see CHANNEL OF THE SAP'S ASCENT;—CAUSE OF THE SAP'S ASCENT.

ASHES.—When vegetables are burnt in the open air, the greater part of their substance is evaporated or dispersed by the action of the fire. But a *residuum* still remains which is incombustible, and which is known by the name of *ashes*. It exhibits a sort of flaky appearance, of a whitish colour, soft to the touch, and crumbling between the fingers to an impalpable powder. It is without taste and without smell.

Herbaceous plants yield more ashes than woody plants, the leaves more than the branches, the branches more than the trunk, and the *alburnum* more than the matured wood. A thousand parts of the leaves of *Æsculus Hippocastanum* gathered in May yielded seventy-two parts of ashes; while a thousand parts of the trunk and branches of the same plant yielded only thirty-five parts of ashes. [Sausure Sur la Veg. chap. ix.] The ingredients which enter into the composition of ashes are many, as we may believe; but the chief of them are the three following—alkalies, earths, metals.—Are these ingredients formed through the agency of the living energies of the plant; or, are

they merely taken up by the root in solution with the moisture of the soil?—See FOOD OF PLANTS.

ASSAFŒTIDA.—This substance, which the chemists place among the Gum-Resins, is the concreted juice of *Ferula Assafœtida*, a plant which grows in Persia and other eastern regions. Its taste is bitter, and its smell insufferably fetid; and yet the Indians are said to use it as a seasoning to their food, and to call it the *Food of the Gods*. This forms a strange contrast to the name which it has obtained in Europe, where it is vulgarly known by the appellation of *Devil's dung*. It is used in medicine as an antispasmodic.

ASSIMILATION.—This term denotes the process by which the nutritive portion of the vegetable aliment is incorporated into the substance of the plant.—See NUTRITION.

AXILLA.—The axilla, or axil, is the angle which the leafstalk forms with the upper part of the stem or branch, and which always contains a bud.

BARK.—The bark is the outer or external portion of the stem, encircling or enclosing the wood or pith. In young subjects it is of a flexible and leathery texture, consisting first of an epidermis or external pellicle; secondly, of a layer of cellular tissue, called the cellular integument; and, thirdly, of a number of thin, reticulated, and concentric layers, known by the name of the cortical layers. But in old subjects it is often highly indurated, approaching in its texture to that of wood, and exhibiting no longer any traces of epidermis or of cellular integument; but splitting into wide chinks or fissures, as may be seen in the rift and aged trunks of the Elm and Fir. In the root it is said to be generally thicker than in the stem and branches, and of a dull and earthy colour, affected a little by the soil in which it grows; but in the root of the Elm it is reddish, in that of the barberry it is yellowish, and in that of the *Cytisus* of the Alps it is said to be black. Its different parts will be described under their several and respective titles.

BARREN FLOWERS.—Barren flowers are flowers that produce anthers but not pistils. Of this there are three cases: First, when flowers containing stamens only, and flowers containing pistils only, are produced on the same plant. In this case the plant is said to be monœcious, as in *Corylus* and *Alnus*. Secondly, when flowers containing stamens only, and flowers containing pistils only, are produced on different plants. In this case the plant is said to be Diœcious, as in *Humulus* *Lupulus*. Thirdly, when hermaphrodite flowers, and flowers containing stamens and pistils separately, are produced on the same plant. In this case the plant is said to be Polygamous, as in *Atriplex*.

BEAK.—The beak is an appendage of the persistent style, elongated but not feathered. It is exemplified in the genus *Scandix* and several other of the *Umbelliferae*.

BEARD.—The beard is a tuft of fine hairs or bristles, issuing, in most cases, from the calyx or corolla, but sometimes from the other parts of the flower also, as in *Thymus*, *Iris*, *Periploca*. The aggregate of the awns of an ear of barley, or of any of the other grasses, is sometimes called its beard.

BERRY.—The berry is a soft and pulpy pericarp, containing one or more seeds, but not separating into regular valves, nor enclosing a capsule. It is exemplified in the very familiar case of the Currant and Gooseberry.

BIENNIALS.—Biennials are plants living for the space of two years only;—that is, if growing in their natural habitats, and left entirely to themselves. The Carraway, Carrot, and Celery, are examples. The first year they fix themselves in the soil by the root, but send up no stem. The second year they send up a stem, produce flower and fruit,—and perish. Thus they belong to the class of plants called monocarpous, that is, plants flowering or producing fruit but once. The production of the flower has exhausted their vitality, and numbered the days of their existence; restricting the annual to one year, the biennial to two years, and giving to others, as to *Agave Americana* and the Talipot Palm, an indefinite number of years. They owe their death to the process of their fructification, which, if retarded, prolongs, and, if accelerated, shortens their existence. Wheat sown in the spring lives but six months; but sown in the autumn it lives twelve. Biennials put into situations unduly warm become annuals; put into situations unduly cold, they become triennials. The *Agave Americana* in its native climate flowers after a period of only four or five years, but in the climate of England it does not flower till after a period of fifty or of a hundred years. Thus the terms of the duration of these plants may be either abridged or protracted by the contrivances of art.

BITTEN ROOT.—The bitten or truncated root is a root tapering gradually, like the spindle-shaped root, but terminating abruptly, as if the lower extremity were cut or bitten off. It is exemplified in the plant called Devil's-bit, or Devil's-bit Scabious—*Scabiosa Succisa*, which affords at the same time an example of the whimsical and superstitious notions of the simplists of ancient times with regard to the virtues of plants. Almost all plants were believed to be possessed of some peculiar and medicinal properties; and the Devil was believed to be—what it would certainly not have been very orthodox to doubt—the grand and leading agent in the production of all evil whatsoever

affecting the interests of man. Now here was a plant with part of the root bitten off, and what was the inference that seemed the most probable?—Why, that the part wanting, was wanting through the fraud and malice of the Devil, bitten off out of sheer hatred to mankind, and secreted or destroyed on account of the peculiar potency of its medicinal virtues. But, unhappily for the patients of modern times, the medicinal virtues of this plant do not, upon enquiry, turn out to be any thing remarkable, and the part bitten off has been accounted for in another way.—The *rationale* of the phenomenon is this.—A portion of the lower extremity of the root decays and perishes, annually, in the soil; while the remainder, together with the lower extremity of the stem or collar, protruding new fibres, sinks down or is drawn down to supply its place. Hence the deficiency of the part in question, and the bitten appearance which the root always exhibits.

BLANCHING.—Blanching is a process invented by the gardener for the purpose of rendering the stems or leaves of certain esculent plants crisp and tender. It consists in excluding them partially from the action of light, as in the earthing up of celery, or tying up of the leaves of lettuce. It is, in short, an artificial etiolation.

BLEEDING.—If the branch or trunk, or even the root of a tree, is laid open or fractured in the course of the spring, whether by intentional incision or by accidental wound, the sap will immediately begin to flow, and will in some cases continue to be copiously discharged, perhaps for several days, or at least till the wound is cicatrized; and if it is again opened the sap will flow afresh. This is what is usually denominated the bleeding of plants, and is well exemplified in the Vine, Birch, Maple, and Walnut, as affording a most copious discharge. A small branch of Vine has been known to yield from twelve to sixteen ounces in the space of twenty-four hours. A Maple tree of moderate size yields about 200 pints in a season, which may be manufactured into a tolerably good sugar; and a Birch tree has been known to yield a quantity of sap equal to its own weight, which may be manufactured into a very pleasant wine.

But what is most to be wondered at in the case of the bleeding of plants, is that the most copious discharge does not seem to injure the individual in any material degree. Duhamel selected several strong and healthy vines as the subject of experiment, some of which were trimmed in the usual way, and others made to bleed copiously; but the latter were afterwards as vigorous and productive as the former. The American Maple will yield its usual quantity of sap for a number of years in succession, though it requires now and then an interval of rest. The plant always bleeds the most freely about the time of the opening of the bud; for in proportion as the leaves expand the sap

flows less copiously, and when they are fully expanded it ceases entirely. It is on this account that the flowing, as the forester calls it, of the oak-tree is always an operation of the spring, when the bark, full of tannin, and the alburnum full of sap, are easily disunited.

BLIGHT.—Much has been written on the nature of blight, and in proportion as words have been multiplied on the subject, the difficulties attending its elucidation have increased. This disease was well known to the ancient Greeks, who were, however, totally ignorant of its cause; regarding it merely as a blast from heaven, indicating the wrath of their offended deities, and utterly incapable either of prevention or of cure. It was known also to the Romans under the denomination of *rubigo*, who regarded it in the same light as the Greeks, and even believed it to be under the direction of a particular deity, Rubigus, or Robigo.

“Aspera Robigo, parcas Cerealibus herbis.”

OVID. FAST., Lib. iv. 911.

It is still well known, from its effects, to every one having the least knowledge of husbandry or of gardening; but it has been very differently accounted for. Yet there is no one cause that will account for all the different cases of blight, though they have been supposed to have all the same origin. If we take the term in an acceptation limiting it to atmospherical influence merely, it will include the two following species—blight originating in cold and frosty winds, and blight originating in a sort of sultry and pestilential vapour.

The first species occurs chiefly in the season of the spring. If the weather is prematurely mild, the blossom is prematurely protruded, which, though it is viewed by the unexperienced with delight, yet it is viewed by the judicious with fear. For it very often happens that this premature blossom is totally destroyed by subsequent frosts, as well as both the leaves and shoots, which consequently wither and fall, to the evident injury, if not to the death, of the plant; while the juices now stopped in their passage swell and burst the vessels, and become the food of innumerable little insects that soon after make their appearance. Hence they are often mistaken for the cause of the disease itself; the farmer supposing that they are wafted to him on the east wind, while they are only generated in the extravasated juices as forming a proper nidus for the egg of some fly or aphid newly hatched. Whence did the first fly come?—From the hybernacle of the egg out of which it sprang, deposited in the shoot or bud of some neighbouring plant or other fit *nidus*; though no one has yet discovered the winter quarters of the eggs of *Aphis Humuli*, so destructive in its ravages among the leaves of the Hop-plant.

The second species generally happens in the summer, when the herb

or grain has attained its full growth, and when there are no cold winds or frosts to occasion it. Such was the blight that used to damage the vineyards of ancient Italy, and which is yet found to damage our Hop plantations under the name of fire-blast, occurring most commonly about the end of July, when there has been rain with a hot gleam of sunshine immediately after. "Wheat is also affected with a similar blight, and about the same season of the year. In the summer of 1809 I had watched the progress of the growth of a field of wheat on rather a light and sandy soil, merely from having had occasion to pass through it every Sunday in going to serve a church. It came up with every appearance of health, and also into ear, with a fair prospect of ripening well. I had taken particular notice of it on a Sunday about the beginning of July, as exceeding any thing I could have expected on such a soil. But on the following Sunday I was surprised to find a portion of the crop, on the east side of the field, to the extent of several acres, totally destroyed; being shrunk and shrivelled up to less than one-half the size of what it had formerly been, with an appearance so withered and blasted that I for some time imagined I had got into the wrong field. The rest of the field produced a fair crop." [Keith's Phys. Bot. ii. 488.] In the above account, it seems to be taken for granted that the cause of the injury was purely atmospherical. But it would have been well if the straw had been more minutely inspected, to see whether it exhibited any traces of damage done by the growth of Fungi.

BLOOM.—Upon the epidermis of the leaves and fruit of certain species of plants, there is to be found a fine, soft, and glaucous powder. It is particularly observable upon cabbage leaves, and upon plums, to which it communicates a peculiar shade. It is known to gardeners by the name of *bloom*. It is easily rubbed off by the fingers, and, when viewed under the microscope, seems to be composed of small, opaque, and unpolished granules, somewhat similar to the powder of starch; but with a high magnifying powder, in a good light, it appears transparent. When rubbed off, it is again reproduced, though slowly. It resists the action of dews and rains, and is consequently insoluble in water. But it is soluble in spirits of wine; from which circumstance it has been suspected, with some probability, to be a resin. [Mirbel, Phys. Veg. i. 112.] Proust says it is wax. [Ure's Chem. Dict.]

BORING.—Boring is an operation by which trees are often wounded for the purpose of making them part readily with their sap in the season of their bleeding, particularly the Birch tree and the American Maple. A horizontal, or rather a slanting hole, is bored in the trunk with a wimble, so as to penetrate an inch or two into the wood. From

this the sap flows copiously, and though a number of holes is often bored in the same trunk, the health of the tree is not materially, if at all, affected by it: for trees will continue to thrive, though subjected to this operation for many years in succession; and the hole, if not very large, will close up again like the deep incision, not by the broken fibres of the wood, but by the formation of new bark and wood projecting beyond the edge of the orifice, and finally shutting it up altogether.

BOTANY.—The term botany was originally made use of, as it is even now, to denote or to signify the study of plants. Yet the scope of that study has been very different at different periods. It had its origin, we may believe, in the very earliest of times, though we cannot suppose that it was then pursued to any greater length, or with any ulterior view, beyond that of discovering what “was good for food, or pleasant to the eye.” For whether the individual inhabited a paradise, or was driven to the forest for shelter or for shade, the first object of his care must have been that of finding the means of subsistence. Apples, nuts, and acorns, when once seen and tasted, are always known afterwards, as well as the trees on which they grow. The same thing may be said of all other fruits or plants good for food. But it becomes necessary to name and describe them for the benefit of others, or for the purposes of conversation; hence the first botany consisted, doubtless, in the naming and describing of a few esculent plants or fruits,—a presumption which was indeed the fact, as we learn from the history of the Genesis, or first book of Moses, a record commencing with the very creation of man, and embracing a period of upwards of 2000 years. There we find the names of several of the most important esculents,—the tree of the knowledge of good and evil, the tree of life, the fig, the vine, the olive. But plants that are noxious, whether to the eater or to the growth of such as are esculent, require to be named likewise; “thorns also and thistles shall it bring forth to thee.” So also plants that are sanative or medicinal; “spicery, balm, and myrrh.” There could not yet have been any thing like scientific description, and much less any thing like scientific arrangement. Yet we find plants already distributed into three grand groups—trees, herbs, grass. We find also the distinctions of seed, fruit, corn.

In process of time the list of plants named became much more copious, as may be seen by perusing the remaining books of Moses. This relates to the botany of the Israelites only. But about the same period we begin to discover, in the earlier or fabulous history of the Greeks, some faint indications of the dissemination of botanical knowledge beyond the encampments of the nomadic tribes of Israel, or

even the pale of the Promised Land. Medæa is represented by the poets as being so deeply skilled in the magic powers and properties of herbs as to enable Jason, by means of her instructions in the use of them, to perform the otherwise impracticable conditions of obtaining the Golden Fleece. Also Æsculapius is said to have been so thoroughly learned in the medical virtues of herbs as to be able by means of them to raise the dead to life. If these accounts are fabulous with regard to the presumed virtues of plants, still we hold them to be authentic with regard to the progress of botanical study.

The Jews, at a later period, had a botanical writer in Solomon, of whom it is said that "he spake of trees, from the cedar tree that is in Lebanon, even unto the hyssop that springeth out of the wall." But as his book on botany, being, as we may presume, not dictated by inspiration, nor guarded from accident by any extraordinary or miraculous means, has long been irretrievably lost, it is impossible to say what its precise character or object may have been.

The Greeks, in the earlier period of their authentic history, had Pythagoras, Anaxagoras, Empedocles, and Democritus, and, in a later period, Hippocrates, Aristotle, and Theophrastus, all of whom wrote or taught something on the subject of plants, dietetical, medical, or physiological, and thus for the first time extended the scope of the study of botany to its due limits—making it to include not merely the naming and external description of plants, but also the anatomy of the vegetable subject, and the phenomena of vegetation.

The earlier Romans had also their botanical writers, who were finally all eclipsed in the splendour that surrounded Dioscorides and Pliny, illustrious in the annals of botany, and long regarded by the learned as the most infallible guides to the study of plants, which had languished during the period of the dark ages, but which began to be again pursued with increased activity about the period of the revival of learning in Europe, of which we have the proof in the labours of Brunfelsius, who had the merit of introducing the aid of figures, an example that was speedily followed by that of Dodonæus, Matthiolus, Delachamp, and the elder of the Bauhins, on the Continent, and of Turner, Gerard, and others, in our own country.

Still botany was merely descriptive, and its specific descriptions loose and inaccurate; and still there was no botanical method that could be called scientific, though the necessity that existed for the introduction of a scientific method was becoming every day more urgent, from the vast accumulation of new specimens that were now pouring in upon botanists from all quarters of the globe. The first hints on the subject of a legitimate method were thrown out by Gesner. But the first attempt at scientific arrangement was made by

Cæsalpinus, whose method was followed by that of Ray, Tournefort, and others, each of whom did something to the advancement of science, and developed views important to future enquirers. But it was reserved for the great Linnæus, with the profoundly philosophical Jussieu, to give the finishing touch to the work of botanical arrangement, and to establish on a lasting basis the laws of generic and specific discrimination, description, and nomenclature; simplifying and giving perspicuity to the whole, and elevating the study of systematic botany to the high rank which it now holds in the scale of human knowledge.

By a happy coincidence for botany we find that while the arrangement of plants was engaging the attention of philosophers, and rapidly advancing towards the state in which it now stands, so also was the physiology. This was revived, or rather begun anew, by Grew and Malpighi, about the end of the seventeenth century, and pursued with much success. It was afterwards advanced by the labours of Linnæus, in the establishment of his sexual system, as also by Hales, Duhamel, Hedwig, Spallanzani, and still more recently, as well as down to the present time, by Knight, Bauer, Brown, with a host of continental writers, among whom we may specify Gærtner, Sprengel, Defontaines, Decandolle, Brongniart, Amici. But chiefly it has been advanced by means of the application of pneumatic chemistry, which, under the happy auspices of Priestley, Ingenhoutz, Senebier, Saussure, Gay Lussac, Ellis, and Davy, has done more to elucidate the phenomena of vegetation than all other means of investigation put together, and has placed our knowledge of the physiology of vegetables upon a foundation that cannot be moved.

Thus the term botany, as comprehending the two grand departments of the study of plants,—the systematic and the physiological,—is restored to its legitimate use, and embraces every thing that is useful or desirable to be known concerning plants,—a study of immense magnitude; involving a competent knowledge of the systematic arrangement and discriminative marks of fifty thousand species, and their uses; together with the whole of the phenomena of vegetation, and laws of vegetable life; and still there are regions of the earth's surface unexplored, and flowers without a name (*et sunt sine nomine flores*). But as botany is a subject of such immense magnitude, there are few who find themselves in a capacity to embrace it in its full extent, and many who must be content to confine themselves chiefly to one or other of its two grand departments. If to the former, they are systematists, or botanists *par excellence*; if to the latter, they are phytologists.

BOYAUX.—A term introduced by M. Adolphe Brongniart to denote

the tubes that issue from the grains of pollen upon their contact with the stigma, and descend through the style by elongation, till they reach the ovary, carrying with them the *materiel*, or principle, of fecundation. In the books of English writers they are usually called pollen tubes.

THE BRACTE.—The bracte is a floral leaf situated on the peduncle or common axis of the fructification, and often so near to the flower as to be mistaken at first sight for its calyx. This is particularly the case in the genus *Nigella* and some species of *Helleborus*, in which, however, it is known not to be a calyx from its protracted duration, which is generally equal to that of the other leaves of the plant; whereas the calyx either fades with the flower, or, at the latest, when the fruit has reached maturity. But though the bracte is situated for the most part on the stem or peduncle, yet there are cases in which it is situated also on the calyx, as in several species of *Mussenda* [Smith's *Introd.* 222], and even on the fruit itself, as in *Mespilus Germanica*, and some of our varieties of Pears. [Keith's *Phil. Bot.* ii. 294.]

The figure of the bracte is sometimes that of a calyx, as in *Royena Villosa*; or of a scale, as in *Lonicera Nigra*; or of a thorn, as in *Attractylis Cancellata*; or of a bottle, as in *Ascium Coccinium*. But its general form or aspect is that of a leaf, though not always similar to the leaf of the plant. The colour is generally green, as in *Hypoxis Erecta*, but it is also often tinged with a variety of different shades. In *Tilia Europæa*, which affords a singular and striking example of the bracte, it is of a pale yellow; in *Salvia Horminum* it is of a beautiful purple; and in *Bartsia Coccinea* it is of a bright scarlet, giving it at a distance the appearance of a corolla. In *Melampyrum Arvense* the lower bractes of the spike are green and the upper ones coloured, passing as it were by a regular gradation from real leaves to real bractes. They are solitary, or in pairs, or multiply, as in *Bartsia*, in which they form a sort of tuft or bunch at the end of the stem—or, in language strictly botanical, a coma. Dr. Lindley [Introd. to Bot. 102] seems to regard the involucre of the umbelliferæ, the scale of the amentum, the spathe of the palmi, and the glume of the grasses, as being species of bractes. With great deference to the authority of Mr. Lindley, we think it would be more conducive to the purposes of perspicuity to regard them as being rather distinct species of floral leaves, of which the bracte itself is one. But we are ready to adopt his nomenclature of the chaffy coverings that envelope the grains of the grasses; calling those that include a locusta, or partial spike, *glumes*; those that include the individual grain, *paleæ*; and those that invest the base of the germen, *scales*.

BRANCHES.—The branches are the divisions of the trunk, or *caudex*

ascendens, originating generally in the upper extremity, but often also along the sides. The primary divisions are again subdivided into secondary divisions, and these again into still smaller divisions, till they terminate at last in slender twigs. In their insertion or distribution they are opposite, or alternate, or verticillate, or scattered. In their position they are vertical, that is, lying close to the stem; or spreading, that is, forming a conspicuous angle with the stem; or divergent, that is, expanding horizontally; or deflected, that is, hanging down so as to form an arch, as in the Weeping Ash, or Willow. In their size they are proportioned to the dimensions of the trunk, expanding, in trees of large growth, to a great distance from the centre, and forming a sort of secondary trunk. The horizontal branches of a full-grown Calabash-tree are said to be from forty to fifty feet in length; while the horizontal branches of what is called the Live-oak of East Florida are said to extend to upwards of fifty paces. [Bartram's Travels.]

The most beautiful specimens that England affords of plants with wide-spreading branches, are undoubtedly those of the Beech-tree; and the finest we have ever had an opportunity of admiring are those of Eastwell Park, Kent, a seat of the Earl of Winchelsea. Expanding their aged and venerable arms in the full maturity of their growth, dignified in their elevation, and clothed with the pleasing verdure of their glossy leaves, they excite in the breast of the spectator emotions approaching to the sublime, and yet they are not so conspicuously remarkable for vastness of dimension as for beauty and symmetry of contour. The measurement of one of the handsomest of them was as follows: girth of the trunk, close to the soil, from eighteen to twenty feet; height clear of branches, from seven to eight feet; horizontal growth of the lower branches, thirty-six feet, which, with half the width of the stem, gives a semidiameter of thirty-nine feet, and consequently a diameter of seventy-eight feet; slanting extent of the upper branches, such as to give to the group a sort of globular contour, as regular as if it had been clipped with shears, with an estimated elevation of from sixty to seventy feet. Think of the cooling and delightful shade afforded by this ample expansion, as filled up with its summer garniture of leaf and flower, and you have a type before you similar to that from which Virgil drew when he said or sang—

“Tityre, tu *patulæ* recubans sub tegmine *fagi*,
Silvestrem tenui Musam meditaris avenâ.”—ECLOG. i. 1.

Indeed, we are of opinion that no reader of Virgil is competent to form a correct or adequate idea of the beauty of the distich now quoted till he has seen some such trees as those now described. The Beech-trees

of Knowle Park, near Seven Oaks, are said to be of dimensions still larger; and the far-famed Beeches of Knockholt are said to be the largest in England.

BRISTLES.—Bristles are the short, stiff, and sharp-pointed hairs with which the stem and leaves of certain species of plants are densely crowded, as those of *Borage* and *Viper's Bugloss*.

BUDS.—Buds are small and ovate or conical-shaped substances, issuing from the axil of the leaves or extremity of the branches, and containing the rudiments of future branches, leaves, or fruit, but not detaching themselves spontaneously from the plant and forming new individuals. Situated in the above positions, they are said to be normal or regular; situated in any other position, they are said to be adventitious, as in *Malaxis Paludosa*, in which they issue from the leaf; or as in *Prunus Lauro-Cerasus*, in which they are occasionally to be found issuing as if fortuitously from various parts of the body of the stem. They are composed externally of a number of concave and overlapping scales, that protect the enclosed germ from the injuries of the atmosphere, and are connected with the stem or branch by means of a short and fleshy pedicle, in which the scales originate. The bud of the American Walnut is said to be the most magnificent of all known examples, though the bud of the Horse Chestnut, *Æsculus Hippocastanum*, is, as we believe, but little inferior to it.

Buds produce leaves only, or flowers only, or leaves and flowers together. The two former varieties may be seen in the buds of the Peach-tree; the latter in those of the Horse Chestnut. Yet all plants are not furnished with buds—that is, with buds covered with overlapping scales. Annuals are altogether destitute of them, and even trees and shrubs do not produce them in hot climates. But in this country, and in all cold countries, the buds of trees and shrubs are universally furnished with overlapping scales, and without the intervention of such buds no new part is added to the plant. Buds have not been found to be of much use to botanists in the discrimination of species, though they may serve occasionally to distinguish plants in the winter; and gardeners do, in fact, distinguish almost all their plants by the bud.

As buds produce either leaves or flowers, or both, it was to be presumed that the leaves and flowers exist in the bud in an incipient state long before the period of their evolution—a fact that dissection has demonstrated.

If the scales of a leaf-bud are taken and stripped off, and the interior part carefully opened up, it will be found to consist of the rudiments of a young branch, terminated by a bunch of incipient leaves imbedded in a white and cottony down, being very minute but complete

in all their parts, and folded or rolled up in the bud in a peculiar and determinate manner. This has been denominated the foliation of plants, and reduced by Linnæus to ten different modes:—*The Involute*, in which the lateral margins of the leaves are rolled inwards, on both sides—the Apple-tree. *The Revolute*, in which the margins of the leaves are rolled backwards on both sides—the Water-lily. *The Obvolute*, in which the margins of one leaf are enclosed in the margins of another—the Pink. *The Convolute*, in which the leaf is rolled up in the form of a scroll—the Apricot. *The Imbricated*, in which the several leaves overlap and infold one another—the Laurel. *The Conduplicate*, in which the leaf is folded up into two parallel halves—the Cherry. *The Equitant*, in which the leaves are conduplicate, but enclosing others—Iris. *The Plaited*, in which the leaves are doubled up like the folds of a fan—Ladies' Mantle. *The Reclined*, in which the leaves are bent back towards the footstalk—Anemone. *The Circinal*, in which the leaves are rolled in spirally—Ferns.

If the scales of a flower-bud are taken and stripped off, and the interior part carefully opened up, it will be found also to consist of the rudiments of an incipient flower, exceedingly small and minute, but complete in all its parts, and folded or rolled up in a peculiar and determinate manner, similar to that of the folding up of the leaves, and designated by the same or by similar terms. It was first noticed and described by Grew [Anat. of Plant. b. i. ch. 5.], and denominated afterwards by Linnæus the æstivation of plants.

“In the month of March, 1810, I opened up a bud of the Horse Chestnut, which had not yet burst its scales. The scales, about fifteen or sixteen in number, being removed, were found to contain one pair of opposite leaves now laid bare, the divisions of which were closely matted together with a fine down. The leaves, upon being opened, were found to enclose a flower-spike consisting of not less than 100 florets, closely crowded together, and each enveloped by its downy calyx, which, when opened, discovered the corolla, stamens, and pistil, distinct, as also the rudiments of the future fruit discernible in the ovary.” [Keith's Phys. Bot. i. 280.]

Much has been written by phytologists, and many opinions have been hazarded, about the origin of buds. Pliny believed them to be formed from the pith, but without assigning any specific reason as the ground of his belief. Malpighi believed them to be formed from the pith, or cellular tissue, which he regarded as viscera peculiarly destined to the elaboration of sap, and protrusion of future buds. Duhamel seems to have entertained different opinions on this subject at different times. In the outset of his researches he believed buds to be formed from the wood, or from the pith of the former year. But

what are we to say of the first year itself? Afterwards he regarded them as proceeding from pre-organized germs existing in the elaborated sap, and deposited by it in the course of its descent from the leaves so as to pervade the whole plant. Where they were formed we are not told. Some have contended that buds are generated only from the *plexus* of the vessels of the inner bark; because, perhaps, it is by the inner bark that the union of the graft and stock is effected in the well-known operation of grafting. Mr. Knight ascribes to the descending proper juice, that is, to the elaborated sap as it descends through the alburnum, the capacity of generating new buds wherever they may be wanted in the economy of vegetation. Hence the origin of any bud cannot be more deeply seated in the stem than the layer of alburnum from which it is protruded. M. Du Petit Thouars, an able and distinguished botanist rather than an orthodox phytologist, regarded all buds as originating in the axis of the stem or branch that bears them, which, though they may not be protruded into shoots till after many years, are annually pushed outwards in a horizontal direction into every new layer of alburnum, leaving a streak of parenchyma behind them, altogether different from the medullary rays, which indicates their path and connects them with the central pith.

This doctrine has been taken up by a late phytological writer [Lib. of Useful Knowledge], and pushed as far as it can well be made to go. We believe it to be partially founded in truth, as the aspect of the horizontal section of a stem or branch of a Willow will readily show—that is, if the streak of the parenchyma is to be regarded as a good evidence. But this streak is not discernible in all stems. You cannot discern it in the section either of the oak or of the elm. Hence the affirmative of the proposition is not universally true; and certainly its negative is not universally false: for it has been shown by the Rev. Patrick Keith, in a paper published in the sixteenth vol. of the “Transactions of the Linnæan Society,” that stems do occasionally protrude adventitious buds which could not possibly have made their way from the centre to the surface in a horizontal direction,—namely, buds originating in the lip that is formed over the layer of alburnum which may have been laid bare, or may have lost its vitality, through means of accidental decortication.

On the lip that was forming in the summer of 1828 over a wound with extensive decortication, inflicted on the stem of an Elm-tree apparently several years before, two shoots were protruded of at least six inches in length. They had no radiant or horizontal connexion with the centre, on account of the intervention of the dead layer of alburnum, which had been laid bare, with loss of vitality, by the wound, and exterior to which the medullary rays began anew in a

totally different direction. Hence it follows that an adventitious bud does not always originate in a germ generated at the primary development of the stem or branch on which it appears; and that a plant may contain latent germs besides those that are annually pushed outwards in a horizontal direction.

This fact gives a plausibility to the hypothesis of Knight and of Duhamel. For if the incipient bud is not actually formed out of the descending and elaborated sap, it seems to be at least carried along with it in the course of its distribution.

But admitting that buds have their origin in one or other of the parts in question, by what means is their generation effected? The hypothesis of Duhamel and Knight does not well account for the position which buds are known to assume upon the stem or branch—in some species spirally alternate, in others opposite, in others in whirls. The hypothesis of M. Du Petit Thouars accounts better for these facts, but it seems to presume the involution of all buds and of all germs in the germ or embryo that was first created.

We prefer the hypothesis of M. Raspail, by which the rudimentary parts or organs of the plant are regarded as capable of producing their type. Thus the embryonic cell produces embryos, whether seeds or sporules, that detach themselves from the seed or plant and become new individuals; while gemmiferous cells produce buds, floral or foliary, as the case may be, that do not detach themselves spontaneously from the plant, but issue in leaves, flowers, branches; and the vegetative cell produces additional vegetative cells, that go to augment the bulk of the plant. [See DEVELOPEMENT OF THE VEGETABLE OVULUM.]

BULB.—The bulb, an appellation borrowed from the Latin term *bulbus*—

“Candidus Alcathei qui mittitur urbe Pelasga
Bulbus,”

OVID. ART. AM. Lib. ii. 42.

is a vegetable body somewhat affinal, or rather analogous, to the tuber, which, under the form of a flattened disk, or of a depressed cone, protrudes radical fibres from below, and leaves with a scape, or with a stem, or even with nascent bulbs, from above, lodged, till the period of their evolution, in a covering of convergent and imbricated scales, as in *Lilium*, or of concentric coats or layers, as in *Allium*, or of a single and fleshy mass, as in *Crocus* and *Colchicum*. The nascent bulbs, which ultimately and spontaneously detach themselves from the parent plant and form new individuals, are either radical or cauline. If radical, they issue from the axil of the coats or scales, or from the surface of what has been called the radicle-plate, as

in *Allium*, *Lilium*, *Colchicum*. If cauline, they issue from the axil of the leaves or umbels, as in *Dentaria*, *Bulbifera*, and *Allium carinatum*. The bulb, therefore, is not a root, but it is, as Linnæus has well defined it, "the winter quarters of the future plant," furnished with a root suitable to its peculiar structure. Thus bulbs are of three different sorts—the coated, the scaly, and the solid we were going to say, as in *Crocus vernus*, till we recollected that the solid bulb is a designation which some of the leading botanists of the present day seem inclined to discard entirely from their nomenclature. Dr. Lindley says that a solid bulb is a contradiction in terms [Intro. to Bot. 52.] It may be so according to his definition of the term bulb, but was a new definition necessary, or has it tended in any degree to the elucidation of the subject? If botanists were unanimous in the discarding of the old term we should be quite willing to follow their example. But when we find a botanist so distinguished and so experienced as Hooker still making use of the old term [Brit. Flor. 171], we confess that, though we discard it from our vocabulary, we do it with a sort of regret.

By the above means bulbs are now reduced to two species only—the tunicated and the naked. The coated bulb is said to be tunicated because it is covered with a strong and fibrous membrane that invests the whole mass. The scaly bulb is said to be naked because it has no general membrane that invests the whole mass. But each individual scale has its own special *epidermis*, and hence even the naked bulb is well protected.

The flowers of bulbous plants possess great beauty—a property of which the poets, as well as florists, have always known how to avail themselves. If Anacreon has a wreath or garland to weave, he is sure to insert into it a due proportion of lilies; and so are also the modern sons of song:

"The lily it is pure, and the lily it is fair,
And in her lovely bosom I'll place the lily there;
The daisy for simplicity and unaffected air,
And a' to be a posie to my ain dear May."—BURNS.

Some bulbs are useful as articles of food, or rather as giving a seasoning to food, such as the Common Onion; others are useful in medicine, as the Squill, or Sea Onion; and all of them are peculiarly tenacious of potential life, if excluded from the action of the atmosphere. An Egyptian mummy that was lately unswathed in this country was found to grasp in its hand a bulbous root. When exposed to the atmosphere it germinated, and when placed in the soil it grew with great rapidity. It could not have been less than two thousand years old. [Journ. of Roy. Inst. Oct. 1830.] We have

given the account as we found it; yet we ought to add that Dr. Brown, who seems to have had the means of ascertaining the fact, says that the vegetable substance alluded to was not a real bulb after all.

BUNCHES OR TUMOURS.—Bunches or Tumours are partial and irregular enlargements of the organs of the vegetable body affecting the root, stem, branch, bud, leaf; and disfiguring, but not always injuring, the plant. They are very generally caused by the puncture of insects in the depositing of their eggs.

In plants of the genus *Brassica* they occur on the root, and occasion the deformity called *clubbing*, or fingers and toes. The root of these plants is selected by the insect called *Nedyus contractor* as a fit *nidus* for the depositing of its eggs. The eggs are at length transformed into maggots that devour the interior, or divert the juices of the plant to their own nourishment, producing, by the irritation which they thus excite, a large and shapeless tumour, that disfigures the root, and leaves the plant dwarfish, or destroys it entirely. [Main's Illust. 300.]

On the stem they are very common in the Oak and Elm, and are produced, not apparently by the puncture of an insect, but merely by means of some obstruction in the channel of the sap's motion, by which the vessels become convoluted and swell up into a bunch. But on the stem of herbaceous plants bunches are often occasioned by the puncture of insects, particularly on the stem of *Carduus pratensis*. If one of these bunches is cut open in the month of August, it will be found to contain several large and white maggots, the larvæ of *Tephritis cardui* that had laid its eggs in the stem. They do not seem to affect the general health of the plant.

The branches are also liable to become disfigured by bunches or knots. In some cases a knot seems to be first formed like the knots on the stem of the oak, and then to send out a multitude of shoots in the form of an interwoven batch, exhibiting at a little distance the appearance of a wood-pigeon's nest. They occur often on the branches of the Birch-tree, and are known among the peasantry of Scotland by the name of witches' knots. But the large and shaggy bunches that are found on the branches of the Dog-rose are occasioned by the puncture of the *Cynips rosæ*, depositing its eggs in the tender shoot. In the month of August they contain maggots.

The regular developement of the bud is also often prevented by means of the puncture of insects in their selection of a *nidus* fit for the depositing of their eggs. The insect, along with its egg, conveys also to the very centre of the bud a drop of the corroding fluid contained in its bag. Hence the juices are corrupted and extravasated, and accumulated around the egg into a sort of spongy lump, which vegetates

and augments till it forms what is called a gall, affording both food and shelter to the future larva, which, after being converted into a fly, pierces the walls of its prison and escapes into the open air. The most remarkable of such galls are those generated in the bud of the Oak-tree, and known in this country by the vulgar name of oak-apples; some smooth and glossy and changing to red, of the size of a golden pippin, and some covered with a long and white shag, but both occasioned by the puncture of one or other of the several species of *Cynips*. Thus the mystery is unravelled that puzzled Redi, who thought that the grubs of galls were formed by the vegetative power or soul of the plant, not being aware of the deposition of the egg of the parent fly, and not admitting the doctrine of equivocal generation.

Lastly, the leaves, like the buds, are frequently selected as the nidus of insects, and disfigured with galls or excrescences. But the most remarkable gall produced on the leaf, and indeed the most remarkable of all galls, is that which is so extremely useful in the arts of dyeing and of making ink—the nut-gall of the shops. It is generated on the leaf of *Quercus infectoria*, a species of Oak that grows plentifully in the Levant, and is so well known as to require no particular description. It is occasioned by the puncture of the *Cynips Quercus-folii*, or, as Kirby thinks it ought to be called, *Cynips scriptorum*, which deposits its egg in the substance of the leaf by making a small perforation on the under surface. Similar excrescences are generated on the under surface of the leaves of *Quercus Robur*, which, if cut open about the month of August, will be found to contain a maggot.

CALENDARIUM FLORÆ.—Heat, like light, acts as a powerful stimulus to the exertion of the vital energies of vegetables. Seeds will not germinate at a very low temperature, even though placed in a proper soil. Hence, such as are self-sown, as by dropping from the plant in winter, do not generally come up till the spring, when the temperature has been raised to some considerable height by the rays of the returning sun. The same thing happens in the case of the developement of the leaves, flower, and fruit. They do not protrude themselves simultaneously, but at different periods of the spring or summer, dependent, as it would appear, upon temperature. This forms the foundation of what Linnæus has poetically styled the *Calendarium Floræ*, that is *Flora's Almanack*. It embraces the several periods of the leafing and flowering of plants, together with that of the ripening of the fruit.

With regard to the leafing of plants, we find that the Honeysuckle protrudes its leaves in the month of January; the Gooseberry, Currant,

and Elder in the month of February, or beginning of March; the Willow, Elm, and Lime-tree, in April; the Oak and Ash, which are the latest among trees, in the beginning or towards the middle of May. Many annuals do not come up till after the summer solstice, and many mosses not till after the commencement of winter. This gradual and successive unfolding of the leaves of different plants seems to arise from the peculiar susceptibility of the species to the action of heat, as requiring a less or greater degree of it to give the proper stimulus to the vital energy. Hence, Linnæus thought that no rule could be so good for the direction of the husbandman in the sowing of his several sorts of grain as the leafing of such species of trees as might be found by observation to correspond best to each sort of grain, respectively, in the degree of temperature required. But, however plausible the rule thus suggested may be in appearance, and however pleasing it may be in contemplation, it is not likely that it will ever be much attended to by the husbandman, because nature has furnished him with indications that are still more obvious in the very evidence of his own feelings, as well as perhaps more correct; as all trees of the same species do not come into leaf precisely at the same time, and as the weather may yet alter even after the most promising indications.

Like the time of the leafing, the time of the flowering of the plant depends also much upon the degree of temperature induced by the returning warmth of spring, as flowers are protruded pretty regularly at the same periods of the season. The Snowdrop and Mezerion protrude their flowers in February, the Primrose in the month of March, the Cowslip in April, the great mass of plants in May and June; many in July, August, and September; some not till the month of October, as the Meadow Saffron; and some not till the approach or middle of winter, as the Laurustine and Arbutus.

A similar succession takes place in the time of the ripening of fruits, but the plant that flowers the soonest does not always ripen its fruit the soonest. The Hazle-tree, which blows in February, does not ripen its fruit till autumn; while the Cherry, that does not blow till May, ripens its fruit in June. It may be regarded, however, as the rule, that if a plant blows in the spring it ripens its fruit in summer, as in the case of the Currant and Gooseberry; if it blows in summer it ripens its fruit in autumn, as in the case of the Vine; and if it blows in autumn it ripens its fruit in winter. Yet the Meadow Saffron, which blows in the autumn, does not ripen its fruit till the succeeding spring.

Such are the primary facts on which a *Calendarium Floræ* should be founded. They have not hitherto been very minutely attended to by botanists; and perhaps their importance is not quite so much as

has been generally supposed: but they are at any rate sufficiently striking to have attracted the notice even of savages. Some tribes of American Indians act upon the very principle suggested by Linnæus and plant their corn when the Wild Plum blooms, or when the leaves of the Oak are about as large as a squirrel's ears. The names of some of their months are even designated from the state of vegetation. One is called the budding month, and another the flowering month; and the autumn is designated by a term signifying the fall of the leaf. [Barton Elem. p. 248.] Thus the French revolutionists were anticipated even by the Indians in their new names for months and seasons.

CALYPTRA.—The calyptra or veil, is a fine and membranaceous integument in the shape of a hollow cone or extinguisher, that masks the urn-shaped capsule of the Mosses to the summit of which it is attached.

CALYX.—The calyx—an appellation borrowed from the Greek term *κάλυξ*, which signifies an unexpanded blossom or its covering—is the exterior envelope of the flower—that is, where two envelopes are present—encompassing and protecting the interior parts. It may be perceived very distinctly in a Rose not yet fully blown, or in a Poppy beginning to open. Yet it is not to be regarded as absolutely essential to the idea of a flower, for many flowers have no envelope whatever. But in the flowers of perfect plants the calyx is very generally present under one modification or other;—namely, that of the flower cup, the glume, or the scale.

The Flower-cup is a calyx that encircles the flower completely,—its normal shape or structure being that of a leaf or leaves, analogous to the leaves of the stem, and conjoined in a verticillate series. It often assumes the similitude of a real cup, and in former times we had a case in which the similitude was perfect; namely, that of the cup of the Acorn, which botanists of the modern school have lately excluded from the rank of a calyx, and degraded to that of an involucre. We do not complain of the change, we merely state the fact.

In some plants it is thin and membranaceous, as in *Convolvulus sepium*; in others it is thick and fleshy, as in the Rose. In the Compositæ it is a fine down. If it falls before the other parts of the flower it is caducous, as in the Poppy; if it falls with the other parts of the flower it is deciduous, as in the Lime-tree; and if it remains after the other parts of the flower falls it is persistent, as in St. John's Wort. It is adherent and superior, that is, closely investing the ovary by the lower part, but surmounting it by the border, as in Enchanter's Nightshade; or, it is detached and inferior, that is including the ovary, but not adhering to it, as in the Primrose. But according to Ventenat the calyx always originates beneath the ovary, and when it is thought to originate above it, or to be superior, it is only because the lower

part adheres so closely to the fruit as to be scarcely distinguishable from it. It consists of a single and undivided piece, as in *Primula*; or of several distinct pieces called *Sepals*, as in *Rumex*. The introduction of this term, which has been but lately recognised by botanists as legitimate, we regard as an improvement.

The glume is a chaffy and membranaceous envelope, accompanying the flowers of the grasses, and constituting their calyx, but not so formed as to resemble a cup. Yet if it be true that there is no rule without exception, a cup-shaped glume ought to exist. The outer covering of the flowers of *Cornucopia cucullata* has been thought to present that exception; but botanists seem now agreed to regard it as an involucre.

The scale is a thin, chaffy, and membranaceous production, forming part of the fructification of a variety of plants that produce incomplete flowers, and constituting their calyx. It may be seen in the catkins of the Willow and in the cones of the Fir. In the former it is a proper calyx, in the latter it is a common calyx.

CAMBIUM.—When the moisture of the soil has been absorbed by the root, it is carried up by means of the action of the several organs till it reaches the summit of the stem or branches—that is, till it reaches the buds or leaves. In its ascent it is denominated the sap; and as it mingles with such soluble matters as it may meet with in its passage, it is continually adding to the number of its ingredients, and undergoing a partial change in its qualities. It is the grand and primary source of vegetable aliment; though it is not yet strictly alimentary, but rather analogous to the chyle of animals, as absorbed by the lacteals, and carried forward till it is poured into the current of the blood.

At the leaves the sap receives its due elaboration, and from them it is now carried downwards till it reaches the root. In its descent it takes the name of *cambium*, or elaborated sap. It is a limpid, viscous, and mucilaginous fluid, convertible, and in the economy of vegetation converted, into tissue for the formation of new cells or vessels, or into peculiar ingredients of which the cells or vessels may be the repositories. It is now strictly alimentary, and analogous in its function to the blood of animals, visiting all such organs as are yet in full function, and furnishing materials for the addition of new parts. In exogenous plants the new parts are always added to the exterior of the alburnum, and to the interior of the bark, that is the liber, and here it is that the *cambium* is always to be found in full flux in the season of the plant's growth. We cannot therefore doubt that the new layers are formed from it. [See CONCENTRIC LAYERS.] Yet it has been thought that two substances so different in their properties as

bark and wood could not possibly be formed out of the same *cambium*. But why not? The *cambium* is not a simple and homogeneous substance; and if in the animal system bone always finds bone in the same blood, and muscle always muscle, so in the vegetable system bark may always find bark in the same *cambium*, and wood always wood. The organized and living molecule abstracts from the alimentary mass such particles as are suited to its own development, and always produces its own type; and if this wood and bark are found to protrude multitudes of globules from their respective surfaces about the time of the flowing of the cambium, as Dutrochet says they do, we can easily see how they are to be nourished by it.

Further, Dr. Lindley seems to think that the cambium cannot be the source from which the wood is formed even in exogenous plants; because in many such plants wood is not deposited in regular circles, but only on one side of the stem; and because in endogenous plants, which have no cambium at all, wood is yet formed in abundance. [Intro. to Bot. 244.] If there are exogenous plants in which the wood is not deposited in regular circles, they form the exception and not the rule. The point at issue is whether cambium is to be found in such plants on the side on which the wood is deposited. Also, though the course and agency of the cambium, or elaborated sap, is not so palpably obvious in endogenous as in exogenous plants, yet as the elementary organs of both are the same, we may, with Dutrochet, fairly assign to them the same functions—lymphatics to convey the ascending sap;—clôstres to convey the descending and elaborated sap, or cambium;—tracheæ to conduct the fluid of insolation, and medullary cells to diffuse the nervous molecules, as in the stem of *Sago farinifera*. [L'Agent. Immed. 52.]

Finally, Dr. Decandolle seems to be of opinion that the cambium is not fully formed till it has been mixed with sap conveyed to it by lateral communication, through the channel of the cellular tissue or divergent layers. We believe it to be fully formed in the leaf; and if there is a lateral adfluxion of sap through the medium of the cellular tissue, we regard it as serving to dilute rather than to form the *Cambium*.

CANKER.—The canker, or caries, is a disease that chiefly affects the young shoots and branches of fruit-trees, corrupting the juices, and corroding the solid substance, whether of the bark, wood, or pith. Sometimes it makes its appearance upon the epidermis in the form of a black speck, which gradually enlarges by the erosion of the surrounding parts, till the branch or shoot is so weakened by loss of substance that it readily breaks. Sometimes it assumes the form of a ring of scurvy and diseased matter, penetrating the shoot or branch

till it reaches the pith ; and sometimes it originates in the pith itself, assuming the appearance of a black and central thread. It has been thought to be invariably connected with old age. But, however that may be, it is induced or accelerated by stiff and clayey soils, wet sub-soils, injudicious pruning, or accidental wounds. It admits of mitigation, but seldom of a complete cure. The common remedy is the excision of the diseased part and the application of a plaster ; but Sir H. Davy recommended the trial of the application of a weak acid, suggested by the result of a chemical examination of the corrupted matter.

CAP, OR PILEUS.—Of the Stipitate Fungi a great many are furnished with a sort of conical or flattened production surmounting the stipe, and attached to it at right angles, sometimes by the centre and sometimes by the one side. This production has obtained the appellation of the cap or pileus, which its figure suggests, and may be exemplified in *Agaricus campestris*, the true Mushroom.

CAPRIFICATION.—The Fig, *Ficus Carica*, which grows plentifully, and is cultivated carefully, in Italy, Greece, and the islands of the Archipelago, does not bring its fruit to perfection, or is apt to drop it prematurely, unless it is prevented by the intervention of certain specific means. The cultivators of this plant, who are interested in the success of the crop, have long ago discovered the means required, and have been in the habit, from time immemorial, of collecting branches of the Wild Fig, *Caprificus*, and of attaching them to, or of suspending them over, the branches of the cultivated Fig, at the critical and decisive moment, by means of which attachment or suspension the fruit is duly matured, and the hopes of the cultivator consummated. This act is denominated Caprification ; but how is it that the branch of the Wild Fig is thus so happily efficacious ? The effect is the result of the instrumentality of a little gnat, *Cynips Ficus Caricæ*, which lays its egg in the seed-bud of the Wild Fig, and is found constantly, at the due season, fluttering about the fruit. But the fruit of the cultivated Fig answers its purpose equally well, and it is no sooner presented to it than it falls to work, rummaging about, and entering the orifice that leads to the receptacle of the flowers, that it may lay its eggs in the tender buds. It was formerly thought that the premature falling of the fruit was owing to the want of due fecundation, on account of the difficulty of the access of pollen in the ordinary mode of transmission, and in the very common case of the flowers being wholly female, as well as by reason of the structure of the fruit. Hence it was believed that this little busy gnat carried to the interior of the female receptacle the very substance wanted—namely, the pollen of the anthers, some of which must necessarily

have clung to it, in rummaging through a variety of receptacles, till at last the impregnation of the female flowers was effected, and the fruit preserved from falling prematurely. But Decandolle, upon the authority of M. Bernard, circumscribes the instrumentality of the insect merely to that of puncturing the fruit externally, as it would appear, and thus represents the maturation of the fruit as being merely the result of puncture, which is equally efficacious, as it seems, if achieved by any sharp instrument whatsoever. [Phys. Veg. ii. 580.] He admonishes us to beware of confounding this operation with that described by Herodotus in the case of the Date Palm, for there it is the action of the pollen which preserves the fruit from falling. But if similar effects are rightly regarded as proceeding from similar causes, we must still in the case of the Fig ascribe the result achieved by the insect to the agency of the pollen conveyed to the flower-bud, if it be true that the insect enters the interior.

CAPSULE.—The capsule is a dry and membranaceous pericarp, opening, when ripe, in some definite and determinate manner, but separating, for the most part, into valves. It is one-valved, as in *Primula*; two-valved, as in *Circeæ*; many-valved, as in *Oxalis*; or without valves, as in *Fraxinus*.

CARBONIC ACID.—Carbonic Acid, a substance indispensable to the growth and nutrition of vegetables, is an invisible and permanently elastic fluid, composed of two proportions of oxygen and one of carbon or diamond. [Davy's Agri. Chem. Sec. ii.] It is diffused in great abundance throughout the whole extent of the material world. It constitutes one part in the hundred of the air of the atmosphere, and is thus in unceasing contact with the leaf and stem of the plant. It enters into combination with the earths, alkalies, and metals which make part of the solid fabric of the globe; and it forms a notable proportion of the materials of which animal and vegetable bodies are composed. It may be obtained from the surface of liquor in a state of fermentation, or from treating a piece of chalk or marble with dilute sulphuric acid. It is condensable into a liquid, according to Faraday, at the temperature of zero, and under a pressure of forty atmospheres. It extinguishes flame. It is fatal to animals that breathe it. It is heavier than atmospheric air, though universally diffused throughout it. It is absorbable by water or by the moisture of the soil, and thus presents itself of necessity not merely to the leaf and stem of the plant, but to the root also. Its agency in the economy of vegetation will form the subject of a future article,—**ELABORATION OF CARBONIC ACID.**

CARINA.—The carina, or keel, is a term employed by botanists to

denote the lower petal of the corolla of a papilionaceous flower, from its resemblance to the carina or keel of a boat.

CARPELLUM.—Upon the morphological principles of Goëthe, for a time contemned and neglected, but now adopted and illustrated by the most eminent of modern phytologists,—Decandolle, Brown, Du Petit Thouars, and others,—the pistil of every flower is to be regarded as being but a leaf metamorphosed into an ovary with its accompaniments. The expansion of the leaf by the union of its margins rolled inwards forms the ovary, the midrib extended and expanded to a due length and thickness forms the style, and its “denuded, secreting, and humid apex,” forms the stigma. The leaf, thus metamorphosed, is a *carpellum*; and where there are more pistils than one to a flower, they spring from a whirl of leaves, and are CARPELLA; each having its own style and stigma, and each being furnished with a *placenta* originating in some point of the ventral suture. [Lindley’s *Introd. to Bot.* 144.]

CARUNCULES.—Caruncules, or strophiolæ, are small and fungous lumps, or tubercles, situated near the umbilicus of certain seeds. The genus *Euphorbia* furnishes a curious example of a caruncule that covers the foramen.

CARYOPSIS.—By this term botanists denominate a peculiar species of pericarp—dry, indehiscent, one-celled, one-seeded, superior, and adhering inseparably to the proper integuments of the seed, as in *Triticum*.

CASUALTIES AFFECTING THE LIFE OF VEGETABLES.—As plants are like animals, organized and living beings, they are like animals also liable to such accidental injuries and disorders as may affect the health and vigour, or occasion the death of the individual; which is at any rate eventually effected by means of the natural decay and final extinction of all its vital energies. Hence the subject of vegetable casualties divides itself into the three following heads—Wounds, Diseases, Natural Decay;—which see.

CATKIN.—The catkin is a species of inflorescence consisting of an assemblage of incomplete flowers,—that is, flowers destitute of calyx, or of corolla, or of both,—but furnished with a scale like bracte which attaches them to a common and elongated receptacle. It was regarded formerly by Linnæus and many of his followers as a species of calyx; but we believe that no botanist regards it now in that light. It is exemplified in the very familiar cases of the inflorescence of the Birch and Willow-tree.

CAUDEX AND ITS ANALYSIS.—The term caudex seems to have been employed by the Latin Classics to signify merely the stem or trunk of a tree.

“Quin et caudicibus sectis (mirabile dictu)

Truditur e sicco radix oleagina ligno.”—VIRG. GEOR. ii. 30.

Linnaeus employed it to denote the main stock or axis of the plant, as resulting from the full growth and developement both of the radicle and of the plumelet. Hence it is divisible into two distinct portions—the *caudex ascendens*, and the *caudex descendens*; the former corresponding to the trunk or stem, the latter to the root.

If trunks are cut open by the saw or the dissecting knife, they exhibit different degrees of organization, according to the tribe or family to which they belong, ascending from the lowest and least perfect to the intermediate, and finally to the highest and most perfect forms.

In the first division you have the least complexity of organization, and the simplest mode of vegetable structure, as in the class Cryptogamia. Take the thallus of *Tremella arborea*, and inspect it externally. It presents merely the appearance of a sort of irregular mass of wrinkled pulp or jelly of a brown or reddish colour, adhering to the surface of rotten timber or trunks of decayed trees, without any visible root, and without the appendage of either branch or leaf, or of conspicuous flower or fruit. If you cut it open it still presents to you merely the appearance of a mass of pulp, or of parenchyma covered with a tough epidermoid rind,—that is, of a structure wholly cellular.

The second division comprehends the middle orders of vegetables, that is, orders exhibiting more manifest traces of organization than the foregoing, the caudex being now partly vascular, as consisting of an epidermis that encloses a voluminous pulp interspersed with bundles of longitudinal threads or fibres. This mode of structure prevails chiefly in herbaceous and annual, or biennial plants, and necessarily involves some considerable variety,—the pulp being sometimes solid and sometimes tubular; and the fibres being in both cases sometimes scattered and sometimes contiguous, sometimes arranged irregularly and sometimes in a determinate order. If the stipe of *Aspidium Filix-mas* is divided by a transverse section, the section will exhibit an epidermis enclosing a firm and consistent pulp, marked with five circular spots, of a darker colour than the rest, and arranged in a line forming about three-fourths of the circumference of a circle, concentric to the circumference of the stipe. The spots are the divided extremities of five bundles of longitudinal fibres extending longitudinally throughout the whole length both of the stipe and rachis.

The third division comprehends the highest orders of vegetables, that is, orders exhibiting the highest degree of vegetable organization, the caudex being now more decidedly vascular in its structure, as well as more perplexingly intricate, and consisting of an outer, an intermediate, and a central part, each having an aspect and texture peculiar to itself. If the trunk of a tree or shrub, such as that of the Oak or Elder, is divided by means of a transverse section, the parts as above stated will

be distinctly visible. The outer portion is the bark, the intermediate portion is the wood, the interior portion is the pith. The structure of the branches is similar to that of the trunk, as is also that of the root with its divisions till you reach the extreme spongiolæ. Thus we trace in plants the foundation of three grand orders, corresponding pretty nearly to the acotyledonous, monocotyledonous, and dicotyledonous plants of Jussieu.

CAUSE OF THE SAP'S ASCENT.—It was shown in a former article that the sap is in perpetual motion, at least at certain temperatures, and that its motion is from the root upwards. What is the cause of the sap's ascent? The great obscurity in which this subject is unavoidably involved has occasioned much diversity of opinion among phytologists.

Grew states two hypotheses which he seems to have entertained at different periods, though it is not quite certain to which of them he finally gave the preference. In one of them he attributes the ascent of the sap to its volatile nature and magnetic tendency, aided by the agency of fermentation. [Anat. of Veg. chap. iii.] But this hypothesis is by much too fanciful to bear the test of serious investigation.—In the other he attributes the entrance and first stage of the sap's ascent to the agency of capillary attraction, and accounts for its progress as follows. The portion of the tube that is now swelled, being surrounded with the vesicles of the parenchyma swelled also with sap which they have taken up by suction or filtration, is consequently so compressed that the sap therein contained is forced upwards a second stage, and so on till it reaches the summit of the plant. But it is now well known that the agency of capillary attraction is totally inadequate to the production of the effect which is here ascribed to it.

Malpighi was of opinion that the sap ascends by means of the contraction and dilatation of the air contained in the sap vessels. [Anat. Plant. Pars Prima.] This supposition is perhaps somewhat more plausible than either of Grew's; but in order to render the cause efficient it was necessary that the tubes should be furnished with valves, which were accordingly supposed. Yet no fact in the anatomy of vegetables is better established than that of the absence of valves in the vessels with which they are furnished. Thus the opinion of Malpighi was proved to be groundless.

M. De La Hire seems to have attempted to account for the phenomenon of the sap's ascent by combining together the theories of Grew and Malpighi. With the capillary suction of the former, and the presumed valves of the latter, he thought that the sap might be easily elevated to the summit of the plant. Still there was no proof of the existence

of valves; and though Borelli added to the above machinery the influence of the condensation and expansion of the air and juices of the plant as an additional help, yet as this was after all but a combination of the theories of Grew and Malpighi, and as two phytological negatives do not make a positive, no modification of them could be regarded as affording a satisfactory solution of the phenomenon of the sap's ascent.

With this impression upon his mind, and with the best qualifications for the undertaking, Duhamel directed his efforts to the solution of the difficulty by endeavouring to account for the phenomenon from the agency of heat and humidity. [Phys. des. Arb. liv. v.] 'There can be no doubt of the great utility of heat in forwarding the process of vegetation; but it will not therefore follow that the motion and ascent of the sap are to be attributed to its agency. On the contrary, it is very well known that if the temperature exceeds a certain degree, it becomes then prejudicial both to the ascent of the sap and also to the growth of the plant. Hales found that the sap flows less rapidly at mid-day than in the morning [Veg. Stat. Exp. 36], and every body knows that vegetation is less luxuriant at midsummer than in the spring. So also in forcing, the unskilful application of heat is often the destruction of the crop, and many plants thrive best at a low temperature. The *Arbutus*, *Viburnum* *Tinus*, and the Mosses will continue not only to vegetate but to protrude their blossoms even in the midst of the winter. Humidity can scarcely be conceived to act as a propelling cause, though it may easily be conceived to afford a facility to the ascent of the sap in one way or other. In the state of the atmosphere that precedes or forebodes a storm, Duhamel observed that a stalk of wheat grew three inches in three days, a stalk of barley six inches, and a shoot of a vine almost two feet. Yet this is a state that occurs but seldom, and cannot be of much service in the general propulsion of the sap.

Hitherto no phytologist had been lucky enough to suggest a cause of the sap's ascent that could be regarded as at all adequate to the production of the effect; and the first philosopher who may be said to have done so was Saussure the Elder. According to Saussure the cause of the sap's ascent is to be found in a peculiar species of irritability inherent in the sap vessels themselves, and dependent upon vegetable life, in consequence of which they are rendered capable of a certain degree of contraction, according as the internal surface is affected by the application of stimuli, as well as of subsequent dilatation, according as the stimulus is withdrawn; thus admitting and propelling the sap by an alternate dilatation and contraction of the vessels, or of their parts in succession, analogous to the peristaltic movements of the intestines

of animals. If the vessels of vegetables admitted of the peristaltic motion here assumed, we could not doubt the adequacy of the cause assigned; but as the movement in question is merely gratuitous, the theory founded upon it is consequently untenable.

Mr. Knight, who stands peculiarly distinguished among phytologists, presented to the botanical world an additional theory of the ascent of the sap, about the beginning of the present century, resting upon the principle of the reciprocal contraction and dilatation of the plates of the *silver grain*, assisted perhaps by the aid of heat and humidity expanding or condensing the fluids. [Phil. Trans. 1801.] This theory was well received by phytologists, as Mr. Knight's theories have generally been, and regarded as a most plausible solution of a very puzzling question. [Davy's Agri. Chem. Lec. v.] Yet its inadequacy was pointed out by the Rev. P. Keith, in his system of "Physiological Botany," published in 1816. But as it appears from a passage in Lindley's "Introduction to Botany" [p. 236] that Mr. Knight has now abandoned this theory, we have nothing more to say concerning it.

A more recent theory is that of Dutrochet, who ascribes the ascent of the sap to the agency of the two electricities, presuming that when two fluids of different densities are separated by a membrane, whether animal or vegetable, the electricity of the less dense is always *plus*, and that of the more dense always *minus*. Hence there is a strong current of fluid from the former to the latter, and a weak current from the latter to the former. The application of this law to vegetation is as follows. The moisture of the soil is less dense than that contained in the cells of the spongiolæ, and the moisture of the cells first entered less dense than that of the cells placed higher up. Hence the inward or upward current is caused and propagated till it reaches the summit. M. Raspail of Paris, and Dr. Mitchell of Philadelphia, have exposed the unsoundness of this theory by showing that the less dense fluid does not always go to the more dense fluid, whether elastic or non-elastic.—Water still goes to alcohol, though alcohol, by hypothesis, ought to go to it. The rush inwards and outwards M. Dutrochet designates by the terms *endosmose* and *exosmose*, which really mean nothing more than imbibition and exudation, and are consequently not indispensable in physiological nomenclature.

Still the theory of Dutrochet, though stripped of its electrical machinery, affords a very plausible solution of the mystery of the ascent of the sap. The endosmose and exosmose are actual phenomena whether caused by electricity or not, and the process is presumed to be as follows.—First, The moisture of the soil entering the cells of the spongiolæ by endosmose and rendering them turgid, operates as a

vis a tergo, which impels the imbibed fluid into the vegetable lymphatics, and causes the continued ascent of the sap, the wave behind rolling on, as it were, the wave before.—Secondly, The reaction of the vessels aids the ascent of the sap;—not by positive contraction, but by virtue of their tissual elasticity, that property by which the tubes of the Spurge empty themselves when cut or punctured.—Thirdly, The agency of adfluxion is an additional and concurring cause. The cells and vessels that terminate in the leaves are continually losing, by evaporation, part of the fluid which they contain, while their endosmose, always active, immediately fills up the void by the introduction of fluid abstracted from the adjoining organs. This adfluxion of sap towards the leaves extends itself gradually to the very summit of the plant. If the lymphatics are uninterrupted in their course the impulsion extends throughout their whole length. If they are interrupted by knots or diaphragms, each knot or diaphragm is but a new source of endosmose,—the end of adfluxion and origin of impulsion,—and thus the sap ascends to the summit of even the loftiest trees.

Finally, M. Decandolle has presented us with an additional theory, which we believe to be the latest on the subject. He does not allow Saussure to assume a series of contractions in the tubes or vessels through which the sap has been generally supposed to ascend; but he assumes it himself in the case of the cells, which he regards as endowed with a vital contractility analogous to the *systole* and *diastole* of the heart of animals. [Phys. Veg. i. 104.] The proofs of this contractility we have looked for in vain; the argument drawn from poisons being altogether inconclusive; and the presumed contraction and dilatation of closed cells filled with an incompressible fluid being altogether impracticable. Yet by means of this imaginary process the sap is thought to be propelled through the channel of the intercellular openings, its true and only passage of ascent in the estimation of Decandolle. We accept so much of this theory as attributes the ascent of the sap to the agency of the vital energies or affinities of the plant, which does not necessarily involve any such contraction or dilatation as is here supposed,—a thing quite impossible,—but merely the subordinate aid of molecular infiltration—a power unlimited in its capabilities, even though not connected with the economy of life.

CAUSE OF THE CAMBIUM'S DESCENT.—When the sap, in its ascent, has reached the extremity of the stem and branches, and has penetrated into the expansion of the leaves, part of it flies off by evaporation, and the rest is exposed to the action of the several gaseous substances that exist in the surrounding atmosphere. The result of that action, the *rationale* of which will be given in another place, is the conversion of the sap thus exposed into a limpid but viscous fluid, that

now assumes the name of the *cambium*, or elaborated juice—a substance fitted for immediate assimilation, and destined to visit and to augment the parts already formed, or to generate such new parts as remain to be added to the individual; as the new layers of wood and bark by which the diameter of the trunk and branches of exogenous plants is annually augmented. To accomplish this, its motion is of necessity in a direction counter to that of the sap, descending from the summit of the stem to the extremity of the root, as proved by the lump or tumour that is formed above a ligature. What is the cause by which this counter motion is effected?

The descent of the *cambium* was regarded by the earlier phytologists as resulting from the agency of gravitation, owing, perhaps, more to the readiness with which the conjecture suggests itself than to the satisfaction which it gives. But the insufficiency of this cause was clearly pointed out by Duhamel, who observed in his experiments with ligatures that the tumour was always formed on the side next to the leaves, even when the branch was bent down, whether by nature or by art, so as to point to the earth [Phys. des Arb. liv. iv.], in which case the power propelling the *cambium* is acting not only in opposition to that of gravitation, but with such force as to overcome it. This we regard as an unanswerable argument, though it seems to have been occasionally lost sight of.

Mr. Knight, who undertook the investigation of this subject [Phil. Trans. 1804], ascribes the descent of the *cambium* to the joint operation of the four following causes—gravitation, capillary attraction, the waving motion of the plant, and the structure of the conducting vessels. But the arguments that were good against the doctrine of gravitation in the time of Duhamel are good against it now; and consequently we cannot attribute to it any great share in the downward propulsion of the cambium. The inadequacy of capillary attraction is so generally acknowledged, and its influence so far short of what is necessary to produce the effect in question, that there is no occasion to multiply words on the subject; and although it is enumerated as a cause of the *cambium's* descent, yet it is but fair to say that it is not much insisted upon. The waving motion of the plant will facilitate the ascent of the sap, as much as it will facilitate the descent of the *cambium*—that is, it will facilitate motion in any direction. But what will be the amount of its influence in the stiff and stubborn trunk? If by aptitude of structure, Mr. Knight means the existence of valves in the tubes of the bark, as we think he does, we believe that their existence is sufficiently disproved by the almost uniform success of inverted cuttings whether of the Willow or Poplar, as well as of the Vine and Currant. Dutrochet brings his *endosmose* and *exos-*

mose to bear upon the descent of the cambium as he does also on the ascent of the sap, and we think he has succeeded in giving elucidation to the subject. But no cause that is merely either chemical or mechanical will ever be found to give a satisfactory explanation of the movement in question. It may be aided by chemical or mechanical causes ; but not wholly effected by them, as it is essentially a movement resulting from life, and involving the agency of the vital energies and affinities of the plant.

CAOUTCHOUC.—The substance denominated caoutchouc, better known perhaps by the name of Indian-rubber, is the milky juice of certain plants inspissated into a solid form. If an incision is made into the bark of *Hevea caoutchouc*, *Jatropha elastica*, *Ficus Indica*, or *Artocarpus integrifolia*, trees indigenous to India or to South America, a milky juice exudes, which when exposed to air concretes and forms caoutchouc. It may be obtained in any shape by applying it when fluid in thin coatings to a mould and then leaving it to dry. When the first layer has become concrete, a second layer is added, and so on in succession till the fabric has acquired the thickness wanted.

In its pure state it is of a white colour, without taste and without smell, soft and pliable like leather, and extremely elastic. Its black colour is owing to the method of drying the different layers, which is generally that of exposing them to smoke. It is insoluble in water and alcohol, but soluble in ether, in volatile oils and alkalies ; and from the action operated upon it by acids, it is thought to be composed of carbon, hydrogen, oxygen, and azote. [Thomson's Chem. vol. iv.]

It is applied to a great many useful purposes in the domestic and other arts. In the countries where it is produced, the natives mould it into household vessels, or even into boots and shoes. In this country it is no rare thing to meet with it manufactured into water-proof coats ; and in America they are said to make boats of it, which a man, when he has finished his voyage, may fold up and carry on his back.

CELLULAR TISSUE.—The cellular tissue or pulp is a soft and succulent substance constituting the principal mass of herbaceous plants, and a notable proportion of many parts even of woody plants. It abounds in the seed lobes, and in succulent fruits, of which any one may easily satisfy himself by cutting up, whether in a longitudinal or transverse direction, a bean or an apple recently gathered from the stalk or tree. It is also peculiarly conspicuous in the leaf and flower, with their footstalks, when stript of the epidermis. Nor is it wanting even in the stem of woody plants, though much altered in its aspect, and not cognizable, at least as a separate organ, except in the central column of the pith, or in the bark of the young and tender shoots,

where it constitutes a thin layer immediately under the epidermis, and forms a sort of secondary integument, known among botanists by the name of the cellular integument. In the leaves, its colour is generally green; and in the seed lobes, white; while in flowers and fruits it assumes almost all varieties of shade, according to the species of plant, or according to the circumstances in which it is placed. When viewed without the microscope its appearance is that of an assemblage of small and minute granules imbedded in a soft and glutinous substance, as in the greater part of leaves and succulent fruits. But it is only when viewed minutely, and with a good glass, that its true structure is to be detected. Malpighi describes it with his usual accuracy, and compares it to an assemblage of inflated threads or bladders containing a juice. Grew describes it under the appellation of the parenchyma, and compares it to the bubbles formed upon the surface of liquor in a state of fermentation. Duhamel represents it as consisting of a net-work of fibres interspersed with small and granular or bladder-like substances occupying the interstices.

Such were the descriptions of the earlier vegetable anatomists. But later anatomists have been more minute. Mirbel describes it as being composed of clusters of small and hexagonal cells containing a juice. This was an important step in advance, as exhibiting a correct view of that modification of figure which is, perhaps, the most frequent in the composition of cellular tissue. After all we believe the spheroid to be the original and normal form of all cells; all other forms, such as the square, the prismatic, the oblong, the columnar, being occasioned, merely, by the compression or extension of the primitive spheroid. Yet Mirbel does not regard the cells as being distinct and individual organs, such as might be exhibited separately; but merely as being formed of a fine and delicate membrane, so folded or doubled up as to leave the partitions single, and common to two cells. This doctrine Dutrochet has shown to be groundless, and if we repeat his experiments, we shall come to the same conclusion. Take a portion of pulp and put it into a vial filled with nitric acid. Plunge the vial thus filled into boiling water, and the cells will soon become easily detachable, or will soon begin to separate and to present themselves entire in their hexagonal form. Hence where the walls touch the membrane must be double. [Recher. Anat. 11.]

Further, Mirbel regards the partitions of the cells as being perforated by minute holes or pores, for the transmission of sap, or of the other juices of the plant. Yet his doctrine of internal and visible pores has not been generally adopted by other vegetable anatomists. It was attacked and denied rather rudely by the German doctors, Sprengel and Treviranus, and again affirmed and re-asserted by Mir-

bel in his *Defence de ma Théorie*, as well as by Link, Hedwig, and Rudolphi. But as the pores in question have been still more recently and more laboriously searched for, by M. Dutrochet, without success, I suppose we must be content to regard the doctrine as unfounded. Dutrochet says the pores are merely small globules imbedded in the walls of the cells. [Recher. Anat. 40.] It should be added, however, that Mirbel could not account for the fact of the lateral transmission of sap, except through the channel of visible pores, while Dutrochet can account for it very well without them, through means of the agency of molecular infiltration. [Ibid. 48.]

CELLULARES.—This term, which is nearly equivalent to the Cryptogamia of Linnæus, or to the Acotyledones of Jussieu, is now very generally employed by botanists to denote the first branch of that grand and primary division of vegetables by which they are distributed into plants composed merely of cells on the one hand, and plants composed both of cells and of vessels on the other. Yet it is evident that Ferns must be excluded from the cellular department, if structure is to be strictly attended to. There will then remain Flags, Mushrooms, Mosses, Liverworts; and if we are very strict to mark incongruities, we shall find exceptions even in them. Take as an example *Marchantia polymorpha*. The lobes are indeed cellular, but the peduncles are tubular or vascular:—and what are we to say of the fibrous structure of the stipe of many of the Agarics? Is it not vascular also? No,—say the interpreters of the terms of the division; for besides cells it is furnished merely with ducts. Yet what are ducts but vessels? We will not insist upon objections that may be regarded as frivolous and vexatious. We will take the terms as explained by such botanists as have adopted them in their arrangements. “VASCULARES are those which have spiral vessels, being the same as SEXUAL plants, and CELLULARES are those which have not spiral vessels, answering to ASEXUAL plants.” [Lindley’s Intro. to Nat. Sys. xix.] This explanation implies that the whole of the Cryptogamia of Linnæus are *asexual*—an implication not yet universally admitted among botanists; and it shows also at the same time the difficulty of establishing any general rule to which there shall not be found some exception. *Rafflesia*, though furnished with a sexual apparatus, is yet altogether destitute of spiral vessels. At last, 1834, Dr. Brown has discovered spirals, not only in *Rafflesiaceæ*, but also in *Loranthaceæ*, and *Cytineæ*.

CENTRIFUGAL INFLORESCENCE.—If the main axis of the inflorescence of any particular species terminates in a flower, while the other flowers issue from lateral buds originating in the axil of inferior leaves or bractes, and producing a branch or peduncle that carries them from

the centre outwards, then the inflorescence of that species is said to be centrifugal, as in the case of the genus *Euphorbia*, and the upper flowers are the first to expand.

CENTRIPETAL INFLORESCENCE.—If the main axis of the inflorescence of any particular species is furnished with a connected succession of flowers, originating directly in the axis, but without bractes, as in the catkin of the Hazel, or raceme of the Currant, so as that the flowers are developed from the circumference inwards, then, the inflorescence of that species is said to be centripetal, and the flowers at the base are the first to expand.

CHALAZA.—At the point where the ramifications of the umbilical cord, after perforating the primine or testa, commence, there is distinguishable upon the outer surface of the secundine a sort of scar or tubercle called the Chalaza, coinciding with or contiguous to the *hilum* or external scar; though it often happens that the umbilical cord, after penetrating the primine, passes on under the modification of a *raphe* to the opposite side of the cavity, and forms there the internal *hilum* or *Chalaza*, as in the case of the Cherry.

CHANNEL OF THE SAP'S ASCENT.—Before the anatomy of plants had been studied with much accuracy, there was a considerable diversity of opinion among phytologists on the subject of the channel of the sap's ascent. Some thought it ascended by the bark; others thought it ascended between the bark and wood; and others thought it ascended by the bark, wood, and pith, indiscriminately. The first opinion was maintained and advocated by Malpighi, who seems to have taken it for granted that the sap ascends by the bark, merely because the fibres of the bark had been found to be tubular, and hence permeable to fluids. But this is an argument of no weight. It ought to have been shown that the fluid which passes through the bark is sap. The second opinion, namely, that of its ascending between the wood and bark, does not seem to have been entertained by any very distinguished phytologists; but it seems to have been entertained by those who held it, because much juice is found there, because the wood is formed there, and because the graft takes effect there. This opinion was shown by Grew to be erroneous, and a third substituted in its place, namely, that the sap ascends by the bark, wood, and pith, indiscriminately,—by the pith for the first year only, because after that it is dry, but by the bark and wood as long as the plant lives, because, upon cutting a branch or stem, a liquid issues from its general surface, either spontaneously or by pressure. This argument fails just where Malpighi's failed. It does not show that the liquid is sap.

On this subject, as on a great many other phytological subjects, we

are indebted for more accurate views to the experiments of Duhamel and of Knight. Duhamel stripped several trees of their bark entirely, which continued, notwithstanding, to live for several years, protruding new leaves and new branches as before. [Phys. des Arb. liv. v.] It is evident, therefore, that the sap does not ascend through the bark. Mr. Knight succeeded in extracting from some annual shoots a portion of their pith, so as to interrupt its continuity, but not otherwise "materially to injure" the fabric of the shoot [Phil. Trans. 1801], and he found that the growth of the shoots which had been made the subject of experiment was not at all affected by the operation. Hence we are authorized to conclude that the sap does not ascend through the medium of the pith.

But if the sap ascends neither through the medium of the bark nor pith, there is no remaining channel of ascent for it except through the medium of the wood. Is the whole mass of the wood composing the stem or branch, equally well fitted for conveying it? The interior or central part, that has acquired its last degree of solidity, does not seem calculated to afford it a ready passage. Mr. Knight had the operation of girdling performed on an Oak-tree with a view to ascertain the channel of the sap's ascent, and the result was, that the tree exhibited not the slightest mark of vegetation in the spring following. [Phil. Trans. 1805.] It is evident, therefore, that the chief channel of the sap's ascent is the alburnum. Still this is but the enunciation of a vague and indefinite idea. In passing through the channel of the alburnum, does the sap ascend promiscuously by the whole of the cells or vessels composing it, or is it confined in its passage to any peculiar set?

Of the first phytologists, some thought that it ascended through the tubes of the woody fibre; and some, with Grew, only through the channel of the tracheæ. Magnol, in 1709, exhibited the first example of experimenting with coloured infusions. The infusions were absorbed by the roots, and carried up to the very summit of the stem, leaving manifest traces of their ascent in the form of longitudinal streaks or threads. In the stem of woody plants, the streaks were found chiefly in the alburnum, and in that of herbaceous plants, only among the longitudinal bundles of woody fibre. In the root it was the central portion that was tinged the deepest. The colouring matter employed was the juice of *Phytolacca*, or tincture of Madder-root. Thus the extent of the enquiry was considerably circumscribed, and the channel of the sap's ascent shown to be the tubes of the alburnum. Yet the channel of the tubes of the alburnum is still too indefinite, containing, as it does, more species than one. Through which of them is it that the sap ascends?

Mr. Knight prepared some annual shoots of the Apple and Horse Chestnut, by means of circular incisions, so as to leave detached rings of bark, with insulated leaves remaining on the stem. He then placed them in coloured infusions obtained by macerating in water the skins of very black grapes. The sap ascended to the summit of the shoots by what he calls the common tubes of the wood and alburnum; and to the extremity of the leaves by what he calls the central tubes of the bundles of fibres that pass through the leaf-stalk. They are thus synonymous with the small tubes of Mirbel, which, with the spiral tubes, he represents as conducting the ascending sap. Mr. Knight ascribes to the spirals no function whatever.

Still there is a want of definite description in the above view, which Dutrochet has in a great measure supplied. The tubes that convey the sap he designates by the appellation of Globule-bearing tubes, or lymphatics—*les vaisseaux corpusculifères*. They abound in the wood, and particularly in the space that may be said to intervene between the concentric layers of different years. They are studded with small globules or molecules that are imbedded in their walls. They are continued tubes from root to top, and they conduct the ascending sap. Thus they are distinguished from all the other tubes that are found in plants.

Yet, in the face of all this evidence, M. Decandolle, *dans ce dernier temps*, maintains that the sap does not ascend through the channel of any species of tubes whatever, but merely through the intercellular openings—*meats intercellulaires*; because M. Bischoff has said that the conveying of sap is not the normal function of the longitudinal tubes; because many vegetables have no tubes or vessels at all, and yet they have the means of giving distribution to their sap; because sap is known to move in a lateral direction; and because the layers on the under side of a horizontal branch are thicker than those on the upper side. [Phys. Veg. i. 86.] The sanction of Decandolle's name may give weight to these reasons, but we are sure they have no weight in themselves. In the first place, M. Bischoff's assertion is not proved. Secondly, you may as well say, because there are animals which have a circulation or distribution of fluids without a heart, that the heart is not the organ of circulation in those which have it.—Thirdly, the lateral communication of sap is not denied by those who maintain that it ascends through the channel of the longitudinal vessels. Its movement is practicable in all directions, according to the wants of the several organs, and by virtue of the molecular infiltration of the cells,—or, if you will, of their intercellular openings,—but neither solely nor chiefly for the purpose of giving elevation to the sap.—Fourthly, the extra thickening of the layers on the under side

of a horizontal branch is not a uniform result, and if it were, it would be no proof that the intercellular openings are the only channel through which the sap ascends. Hence we regard M. Decandolle as having failed to establish his position.

CHANNEL OF THE CAMBIUM'S DESCENT.—If the stem or branch, or even the root, of a woody plant is encircled by a strong ligature, a tumour is formed immediately above the ligature, but no ligature is formed below it. [Phys. des Arb. liv. v.] Hence the earlier phytologists inferred the descent of a fluid through the medium of the bark. This fluid they found to be the *Cambium*, or elaborated sap. They had not yet begun to enquire by what peculiar vessels it descended. One of the earliest and most satisfactory experiments on this subject is that of Dr. Darwin, which was as follows:—A stalk of *Euphorbia helioscopia*, furnished with its leaves, was placed in a decoction of Madder-root, so as that the lower portion of the stem and two of the inferior leaves were immersed in it. After several days of expectation, the coloured fluid was distinctly seen, upon the inspection of the upper surface of the leaves, to pass in its ascent along the midrib of each. Many of the ramifications were also tinged with red; but on the under surface there was observed a system of branching vessels, originating in the extremities of the leaf, and carrying not a red, but a pale milky fluid, as also uniting into two sets, one on each side of the midrib, and thus descending with it into the leaf-stalk. They were the vessels returning the elaborated sap. The vessels on the upper surface Darwin calls arteries, and those on the under side he calls veins; but in this we cannot follow him.

The next experiments on this subject are those of Mr. Knight. He detected in the leaf-stalk three sets of vessels,—central tubes, which carry the ascending sap, and admit coloured infusions; spiral tubes, which accompany the central tubes as appendages, but which do not seem to conduct any fluid; and external tubes, which convey a descending fluid that is not coloured,—that is, to adopt the language of Mr. Knight,—*the proper juice*. Such are the vessels through which the elaborated sap descends to the base of the footstalk at least; but after quitting the base of the footstalk, and entering the body of the stem, it is still but a continuation of the external tubes by which the descending fluid is conveyed. Mr. Knight describes and represents them by figure, as not only penetrating to the inner bark, but as descending along with it, and conducting the proper juice to the very extremity of the root. The external tubes of Knight seem to be synonymous with the simple tubes of Mirbel, which he describes as being abundant in the bark, and well adapted by the width of their diameter to afford a passage to the proper juice. But Dutrochet at-

tributes this function to a species of vessels which he calls *Clóstres*. They consist of a longitudinal succession of small but united tubes, swollen in the middle, but pointed at the extremities—that is, somewhat spindle-shaped, and often divided by transverse diaphragms. They are destitute of globules, and they conduct the Cambium, or descending and elaborated juice, partly through the channel of the alburnum, but chiefly through that of the bark. [Recher. Anat. sect. i.]

Finally, the channel of the descent of the Cambium, or what seems to be the same fluid under a novel appellation—namely, that of the *Latex*, is regarded by Schultz as being a set of hitherto undetected tubes, which he denominates “*vital vessels*,” lurking under the surface of the bark, and forming a sort of network by means of anastomosing branches, in which the *Latex* or vital fluid may be seen in motion. Now, in all this we find nothing new but the terms employed; for surely the doctrine of anastomosing vessels is not new, and if the *Latex* of Schultz is not the Cambium of Duhamel, we know not what to make of it at all. [See VITAL VESSELS, LATEX.]

CHLORINE.—Chlorine, the Oxymuriatic acid gas of former days, is a permanently elastic fluid of a greenish colour, and of a very disagreeable smell; not known to chemists as a distinct and simple substance till the grand discovery was at last made by Sir Humphrey Davy. It may be procured by the application of heat to a mixture of muriatic acid and manganese introduced into a retort. [Agri. Chem. 40.] It supports combustion, but extinguishes animal life if taken into the lungs undiluted. It is soluble in mercury, and in half its bulk of water, in which last state it destroys all vegetable colours; hence its unrivalled utility in the art of bleaching. It combines with oxygen, and forms both oxides and acids. It combines with hydrogen, and forms the muriatic or hydrochloric acid. It combines with azote and carbon, and forms chlorides. It occurs very sparingly in vegetables, and chiefly under the form of a hydrochlorate of lime, as in the juice of tobacco-leaves; but it seems to be a powerful stimulant to the vital energies of germinating seeds, when applied to them in the state of solution in water.

CHROMULE.—The pulp constituting the parenchyma of the leaves was at one time designated by the appellation of *viridine*, because it is generally of a green colour; but as it is not always of a green colour, M. Decandolle has thought it better to apply to it the appellation of *Chromule*, indicating that it is the substance from which the leaf or flower derives its colour, whether green or otherwise. It is certain that the membrane composing the cells has no colour but what it borrows from the contained pulp, which has itself no colour

till it is exposed to the action of the direct rays of the sun, elaborating the nutriment that it derives, whether from the ascending sap or from the decomposition of carbonic acid gas, or from the direct assimilation of Oxygen. [See the article COLOUR.]

CIRCULATION OF VEGETABLE JUICES.—After the discovery of the circulation of the blood of animals, phytologists who were fond of tracing analogies between the animal and vegetable kingdoms in every thing whatever, began to think that there might exist in plants also a circulation of fluids. There was not indeed any visible apparatus corresponding respectively to the several organs connected with the circulation of the blood of animals, but the defect was supplied in the best way possible. The root was regarded as corresponding both to the mouth and stomach, and as affecting some peculiar change upon the fluid absorbed, that fitted it for the direct nourishment of the plant, as well as possessing also the power of propelling the digested fluid, as the heart propels the blood, to the very summit of the leaf, from which it was again returned to the root, where, mingling with the newly-digested fluid, it was again propelled to the summit as before, and a circulation thus kept up. The vessels in which it was propelled to the summit were called arteries, and the vessels in which it was returned to the root were denominated veins.

But this imaginary structure having no stability in itself, could not be expected to last long. Hence it fell, under the attack of Duhamel, “like the baseless fabric of a vision;” for, though the root may be fitly regarded as analogous to the mouth of animals, inasmuch as it is the organ by which they take up the bulk of their food, yet it cannot be at all regarded as performing the function of a stomach, as it effects no digestive change upon the fluid absorbed. Neither can it be regarded as performing the function of a heart, as it contains no single and propelling organ from which the conducting vessels ramify. Neither are the propelling vessels analogous to arteries, nor the returning vessels to veins, because they do not accompany one another, and because the fluids which they convey are not homogeneous, visiting and nourishing every part of the plant, and returning again to the same point. Hence there is no circulation of the fluids of plants similar to that of the blood of animals; and if it is not similar to that of the blood of animals, it is no circulation at all. It is a distribution of sap, but not a circulation. Even Hales, who contended for an alternate ascent and descent of fluids in the day and night, and in the same vessels, or for a sort of vibratory motion, as he also describes it, gave no countenance whatever to the doctrine of a vegetable circulation, which seems about the middle of the last century to have fallen into disrepute.

Yet this doctrine has been again revived, and has met with the support of some of the most distinguished of modern phytologists. Hedwig is said to have been of opinion that plants have a circulation of fluids similar to that of animals; but we are not acquainted with the arguments on which his opinion was founded. Corti discovered a sort of circulation in the stem of the *Chara*; but it is confined to the internodia merely, exhibiting a descending current on the one side of the cell or duct, and an ascending current on the other, without any intervening membrane to separate them. Mr. Knight also adopts and advocates the doctrine of a vegetable circulation, founding it upon the presumption, or upon the fact if you please, that the proper juice, or Cambium of Duhamel, in descending from the leaf, is expended not only in forming a new epidermis where it is wanted, and a new layer of liber and alburnum, but partly also in entering the pores of the former alburnum, and mingling again with the ascending sap, by which it is carried on till it completes a sort of circulation. [Phil. Trans. 1806.] Whether Mr. Knight still continues to maintain this doctrine we cannot say; but we regard the foundation as being by much too slender to support so weighty an edifice. Lastly, Schultz maintains also the doctrine of a vegetable circulation, grounded on some appearances exhibited in the sap vessels of *Chelidonium majus*. But Dutrochet denies the fact, and contends that the appearances in question are merely an optical illusion, and that the ascending and descending currents are nothing analogous to a true circulation. [L'Agent. Immed. 171.]

The favourable report of the Committee of the Academy of Sciences appointed to examine the merits of M. Schultz's Memoir shows, however, that the circulation which he endeavours to demonstrate is at least well worthy of the notice of the Phytologist; but we confess we agree with M. Dutrochet in thinking that a movement of fluids which is sometimes forwards, and sometimes backwards, and sometimes stationary, in the very same vessels, can have no claim to be regarded as a circulation analogous to that of animals. [See LATEX.]

CLASSIFICATION.—Classification may be defined to be the arranging of the productions of nature in a system, so as either to show the mutual relation which the several subjects or groups of subjects bear to one another in the scale of being, or merely to facilitate our ascertaining of the names which have been imposed upon them by their discoverers or others. In the former case the classification is natural, and is exemplified, as far as regards plants, in the arrangements of Jussieu. In the latter case the classification is artificial, and is exemplified, as far as regards plants, in the arrangements of Linnæus. After all, this distinction, as M. Raspail well observes [Chim. Organ.

p. 84], is more trenchant in expression than in reality, as every good classification will have something in it both of the one quality and of the other.

Linnæus, as every one knows, founded his classes chiefly upon the number of the stamens, and his orders upon the number of the styles. But as distinctions arising from number merely are of themselves entirely artificial, so is the system that is founded upon them. They do not necessarily give any indication of natural groups, and yet it is singular enough that this artificial system has brought together several tribes of plants that are perfectly natural, as the Grasses, the Papilionacæ, the Cruciferæ. Still the study of it gives the disciple but little knowledge of a plant besides the name. He counts his stamens and pistils, and becomes a perfect master of classes and orders; but of the interior and more recondite parts and properties, whether of stem or of flower, by which different genera are allied and connected together, that is, of the natural affinities of plants, he knows nothing. Yet this, as Linnæus himself admitted, is the grand end and aim of all botanical investigation. “*Methodus naturalis, hinc, ultimus finis Botanices est et erit.*” [Phil. Bot. p. 137.] If he had put *fuit* into his maxim it would still have been equally true, for all inventors of systems, even from the earliest times, have had an eye to a natural method. The very division of plants into herbs, shrubs, and trees, the oldest and most popular of all, as well as the most humble in its pretensions, is founded upon a presumed or apparent affinity between the subjects of its different groups. This division is at least as ancient as the age of Theophrastus, if not, rather, as ancient as that of Moses, who speaks of grass, herb, and tree as comprehending and exhausting the whole of the vegetable kingdom. In later times,—that is, after the period of the decline of learning, and interval of the dark ages,—when science began to revive and the seeds of sound investigation to take root, botanists began also to introduce into their lovely study the principles of sound arrangement. Cæsalpinus, Ray, and Tournefort may be named as individuals who contributed much towards the introduction of a natural system, although they were not fortunate enough to stumble upon the true foundation on which alone it can be made to rest. Linnæus himself lent his able aid, and in his “Fragments of a Natural Method” exhibited to the botanical world the proofs of his qualification for the task. There is no saying how far he might have proceeded in the prosecution of his plan, if it had not been that he was so much occupied in the perfecting of his artificial method—a mere stepping-stone to his natural method—that he could not find time for the perfecting of both. But by thus showing his disciples an easy and royal road to learning, he unfortunately, and

without thinking of it, adopted the very means of preventing the student from entering upon, or following up, the intricate and uninviting path that leads by slow degrees to the elevated station from which he may discern the beauties, and appreciate the value, of a natural arrangement.

Yet this laborious and uninviting task was at last undertaken, and prosecuted with a success beyond all that could have been expected. The principal part of the achievement is usually ascribed to M. Bernard de Jussieu, and a subordinate part to his nephew, M. A. Laurent de Jussieu, who is represented as being merely the editor of the writings of his uncle. This erroneous notion seems to have been taken up hastily by the contemporary botanists of this country, and handed down from one to another without much enquiry, till at last it attracted the notice of M. Adrien de Jussieu, as occurring in the Introduction to the *Flora Indica* of Messrs. Wight and Arnott, and called forth a statement that settles the respective claims of the uncle and nephew, and corrects the error that had become too prevalent with regard to them. [Annales des Sci. Nat., Nov. 1834.]

From this we learn that the uncle suggested indeed some of the grand outlines of the *Genera Plantarum*, but gave no filling up. He adopted the germination of the seed and the relative disposition of sexual organs as the only true ground of all systematic arrangement. He formed families, but not classes, and left, in short, nothing in writing but the manuscript catalogues of the garden of Trianon. He died in 1777.

But the *Genera Plantarum secundum Ordines Naturales disposita*, as published in 1789, is something more than a mere catalogue, and M. A. Laurent de Jussieu is something more than its mere editor: he is, in fact, its author. He could not have been the editor of the writings of one who wrote nothing. He could not have gathered all that was necessary to the composition of the *Genera Plantarum* from a few occasional conversations with his uncle. He could not have produced that *chef-d'œuvre* of botanical and logical arrangement without years of close and previous study. Besides, many facts necessary to its final completion were not even known at the time of his uncle's death. Hence we see why the work was not ready for publication before 1789. Hence we see what portion of it is to be ascribed to the uncle and what to the nephew; and we must beware of detracting from the merits of the one for the purpose of enhancing the merits of the other.

In this profound and elaborate work the subjects of the vegetable kingdom are distributed into three grand groups, Acotyledonous, Monocotyledonous, and Dicotyledonous plants. The sections are

founded on the peculiarities of the corolla, and the classes on the insertion of the stamens. Still the advocates of the sexual system say that the method of Linnæus is not more artificial than that of Jussieu, whom they accuse of founding his sections merely on number, as Linnæus founds his classes and orders. [Roscoe on Arrangements, Linn. Trans., vol. xi., or Phil. Mag. and Annals, N. S., vol. vii.—Edit.] But it should be recollected that it is under very different circumstances. Linnæus selects a single species of organ,—the stamens,—and all plants furnished with the same number of stamens are thrust into the same class without reserve, let their natural affinities be what they will. Indeed, natural affinities are not so much as looked for. Thus you have the *Asperifoliæ* and the *Umbelliferæ*, the Bugloss and the *Bulbocastanum*, associated in the same class, without any connecting link, apparent or presumptive, beyond that of their having the same number of stamens; and thus you are under the necessity of separating the single genus *Anthoxanthum* from the natural family of the Grasses, because it happens to have but two stamens to its flower instead of three, which the rest of the grasses have. In the class *Dodecandria* the stamens should be twelve, but by special allowance they may be from eleven to nineteen. The orders exhibit the same incongruities. In *Diandria Monogynia*, you have the Enchanter's Nightshade and Common Ash placed side by side, and in *Pentandria Digynia*, you have *Cuscuta* and *Ulmus*. The styles of *Icosandria Pentagynia* are by special privilege also allowed to be from two to five. Yet these incongruities are not to be severely censured, seeing that the sexual system is actually and professedly artificial.

But in the system of Jussieu several important traits of affinity are already determined before the class is fixed. All plants composing the classes of the first grand group are already connected by the link of their being cotyledonous, that is, by a character founded on the structure of the embryo, and its mode of growth. All plants composing the classes of the *Dicotyledons* and *Monocotyledons* are further connected by their being respectively exogenous or endogenous, accordingly as they belong to the former or to the latter division, that is, by a character founded on the structure of the stem and its mode of growth. These characters are evidently and essentially natural. The *Dicotyledons* are subdivided into minor groups, upon the ground of their being furnished with a calyx and corolla, or with a calyx only, a character found to be of the greatest importance in bringing together natural orders, though not infallible; and the subdivisions are distributed into sections, upon the ground of their being polypetalous, monopetalous, apetalous, or anomalous. If these last characters are not absolutely natural, they are at least absolutely necessary to give facility

to the investigations of the student, and are to be admitted till better characters are discovered; and if you say that they are founded on number merely, it is not exactly so. It is upon structure rather than upon number, a character of more value. For the distinction lies between a corolla, the petals of which are free, and a corolla, the petals of which are united, or it depends upon the absence of a corolla altogether.

Lastly, from the several sections, the classes themselves, which are fifteen in number, derive their immediate origin, upon the principle of the insertion of the stamens, as being hypogynous, perigynous, or epigynous, characters evidently affinal [See Lond. and Edinb. Phil. Mag., vol. v. p. 206, note,] and very available to Linnæus in the circumscription of his 12th, 13th, and 20th classes; for how, without their aid, could he have brought together so many plants connected by natural affinities where his styles and stamens might not have been easily counted? Number is no doubt the work of nature, as well as other characters, but it is found to be liable to great mutability, by an abortion, or by an undue multiplication of parts, and is consequently not to be depended upon in the circumscribing of orders or of genera. It is but a fallacious mark at the best, if taken by itself; for although the genera belonging to a natural order may have all the same number of styles and stamens, yet all plants having the same number of styles and stamens do not belong to the same natural order. Hence it is not from any single trait of resemblance that natural orders are to be determined, but from the sum of the affinities discoverable in the number, form, structure, and position of the several organs composing the stem, leaf, flower, fruit, or seed, the organs last developed being regarded as the most important.

Such is the sure foundation on which the system of Jussieu is built; but still its merits were not at first duly appreciated, whether in France or in other countries. The *éclat* which the name of Linnæus gave to the sexual system was such that no system standing in opposition to it was likely to succeed. Its novelty, its facility, its beauty, were attractions that could not be resisted. Hence Jussieu had many prejudices to encounter, and a host of adversaries to discomfit, before he could divest the natural system of the dreaded difficulties which the study of it seemed to involve, and present it to the botanical student in a fair and favourable light. Yet, in spite of all obstacles, its superiority to every other system forced itself at last upon the notice of botanists, and began to make converts even from among the disciples of Linnæus. In France, the late M. Richard, the Chevalier Aubert du Petit Thouars, M. Mirbel, and the *élite* of the French school were among the first to enrol themselves under the standard

of Jussieu: in Germany, Kunth, Von Martius; and in Switzerland, M. Decandolle. But the botanist whom we regard as having distinguished himself the most conspicuously in the elucidating and perfecting the system of Jussieu, is our celebrated countryman and fellow-Linnæan Dr. Robert Brown, as may be seen by consulting his *Prodromus Floræ Novæ Hollandiæ*, or his papers published in the Linnæan Transactions, particularly that on the Proteaceæ of Jussieu, and on the organs and mode of fecundation in the Orchideæ and Asclepiadeæ; together with that on the genus *Rafflesia*, followed by a paper read at a meeting of the society, June 17, 1834, in which he completes his account of *Rafflesia Arnoldi*, and creates a new order, which he denominates Rafflesiaceæ; all discovering a profundity of research, an acuteness of discrimination, and a peculiarity of tact in seizing the essential character that connects or disunites the subjects of his investigation, which, without his assuming any thing of bold or of arrogant pretension, have elevated him to a rank beyond that of all his competitors, and established his claim to the compliment that was formerly paid to Linnæus, namely, that of his being emphatically, and in the estimation of botanists themselves, *Botanicorum facile princeps*. [Arnott: *Encyc. Brit.*, art. Bot.] We cannot on this occasion pass by without notice Mr. Professor Don, of King's College, London, whom we regard as occupying a very elevated station among the botanists of this country, and second only to Dr. Brown in the number of valuable contributions with which he has enriched the Transactions of the Linnæan Society, all tending to advance and to illustrate the system of Jussieu.

Yet in exalting the merit of Jussieu we have no wish to depress that of Linnæus. Each has his own peculiar claims to our laudatory notice. For if Jussieu might, with propriety, have adopted the language of Horace, and exclaimed,

“Exegi monumentum ære perennius,”—

Linnæus might, with equal propriety, have responded,—

“et multa pars mei
Vitabit Libitinam.”—Lib. III. Ode xxx.

CLAW.—The base or lower portion of the petal of a polypetalous flower is denominated the claw. In some flowers it is extremely short, serving merely as a point of attachment to the receptacle, as in the Rose; in others it is long and conspicuous, as in the Pink.

CLIMATE.—Most plants are affected by climate, and many are confined to a particular hemisphere or latitude which they cannot pass. At the equator and near it you have palms, arborescent ferns, and

forests of leafy evergreens. As you recede from it, you have trees with deciduous leaves—the Coniferæ, the Rosaceæ, the amentaceæ. As you recede from it still further, trees wholly disappear; and grasses and cryptogamic plants form the principal features of a polar Flora. Hence climates and habitations are often the same; and hence plants that are indigenous to the equatorial regions cannot be made to vegetate in high latitudes, except by putting them into a hot-house and keeping up an artificial heat. In like manner plants that are indigenous to the more temperate regions cannot be made to vegetate at the equator because the excessive heat of that region would destroy them. But some plants may be inured to climates of which they are not indigenous provided they are removed with caution, and treated with sufficient care, and not exposed hastily whether to heat or to cold.

Yet nature, always provident for the preservation of all her works, and always fertile in resources for the accomplishment of her object, has furnished some plants with the capacity of vegetating in almost all climates, and of naturalizing themselves in almost any. This is particularly the case with greens and eatable roots, such as cabbages, carrots, potatoes, that is, the common culinary plants most useful to man. Hence they have followed man into all climates and quarters of the globe. It is the case also with some aquatics.—*Lemna minor* has been found throughout almost the whole of Europe, North America, and even Asia; and *Fucus natans*, both under the equator, and within the polar circles. [Willd. Eng. Tr. 395.] Still, climate is not always the same in the same geographical parallel of latitude, whether in the old world or in the new, or whether in parallels south or north of the equator. In the former the temperature decreases more rapidly than in the latter; and beyond the boundary of 34°, the summers, in the same parallels, are colder, but the winters milder. [Humboldt.] Warm climates are also more fertile in species than cold climates, and that nearly in proportion to their distance from the equator. In Spitzbergen botanists enumerate only 30 indigenous plants, in Lapland 534, in Iceland 553, in Sweden 1299, in Brandenburg 2000, in Piemont 2800, in Jamaica, Madagascar, and the coast of Coromandel, from 4000 to 5000. [Willd. Eng. Trans. 374.] But what nature denies us, art will sometimes give us. In our English gardens there are now cultivated, whether in the hot-house, conservatory, or in the open air, upwards of 120,000 varieties of vegetables collected from the different quarters of the globe.

CLIMBING STEMS.—Climbing stems are stems which attach themselves by means of roots, or of other peculiar organs, to other plants or to other bodies for support, not being of themselves sufficiently

strong to assume, or to maintain, the upright position. Such are the stems of the Vine and Ivy. [See the article STEM.]

CLÔSTRES.—The spindle-shaped tubes of Dutrochet, whose office it is to conduct the descending and elaborated sap or *cambium*.

CLOVES.—The young bulbs which originate in the axillæ of the scales of old bulbs are by gardeners called cloves. They “grow at the expense of their parent bulb and eventually destroy it.” [Lindley’s *Introduct.* 52.]

CLUSTER.—A species of inflorescence consisting of an assemblage of flowers, supported upon their own proper pedicles, and attached to a common and elongated axis. It is exemplified in the Currant.

COLOUR.—Decandolle devotes a chapter of his “*Physiologie Végétale*” [chap. viii., liv. 4] to the subject of vegetable colours; in which he embodies almost all that has been either ascertained or conjectured, concerning their cause. It is a neat illustration, *en petit*, of what his work is a happy illustration *en grand*;—that is, of the truth of the maxim of Horace, with regard to the writer who has made himself thoroughly master of his subject;

“Nec facundia deseret hunc, nec lucidus ordo.”—DE ART. POET. 41.

It consists of four sections,—First, Organs exhibiting no colour. Secondly, Organs exhibiting a green colour. Thirdly, Organs exhibiting or changing to any colour but green. Fourthly, Fugacity of vegetable colours. We will endeavour to extract the pith or marrow of it.

I. The colour of plants seems, at first sight, as if it were inherent in their whole mass; but a more accurate inspection shows it is proper only to certain parts. The membranous tissue of the plant, whether cellular or vascular, is uniformly colourless. It is the contained juices only that acquire colour;—a property which they owe to the action of the light of the sun. This is proved by the phenomena of etiolation and of blanching;—the result of vegetation in obscurity, and a fact known to almost every body. If a potatoe happens to throw out shoots while it lies in a dark cellar, they come up pale, weak, and watery. If the leaves of celery, or of lettuce, are excluded from the action of the light of day, they become blanched. Guettard regarded etiolation as the effect of suppressed evaporation. Decandolle does not think the cause assigned sufficient to account for the fact. It is to the want of light and not to the want of evaporation that the plant owes its paleness. Some plants whose leaves do usually assume a specific colour, exhibit parts or patches altogether colourless. Such are the leaves called variegated. The phytologist regards them as indications of disease; the gardener, or the amateur, as an ornament. Decandolle regards them as parts where the chromule,

or contained colourable juice, is deficient, either in its due quantity, or in its due quality. The scarious parts of leaves, or of other organs, he accounts for in the same way.

II. All organs exhibiting or assuming a green colour are found to be capable of decomposing the carbonic acid of the sap or of the air, when exposed to the action of solar light. In this operation the oxygen of the acid is exhaled into the atmosphere, and its carbon fixed in the vegetable tissue. Whence it seems to follow that the green colour of the leaves is owing to the fixation of carbon; for where the decomposition of carbonic acid is not going on the organ remains colourless. The brightness of the green seems to depend upon the degree of light to which the organ is exposed; and yet solar light is not indispensable. Decandolle gave the green colour to some plants of *Lepidium sativum* merely by the light of a few Argand's lamps; but they did not give out oxygen when placed in water.

Still the deposition of carbon caused by the action of solar light does not affect the membranous tissue. Still this tissue retains its original colour and transparency, so that it is only the enchyma or chromule of Decandolle which assumes the green colour. But how does carbon which is black, yield a colour which is green? Senebier solved the problem as follows. Carbon is, in strict propriety of speech, not a black, but a very deep blue; and vegetable tissue is not absolutely a pure white, but rather a pale yellow. Hence, the green is formed by the mixture of a yellow and a blue. This explication, *quoique un peu mecanique*, Decandolle regards as likely to be the true one. Yet we cannot help entertaining some doubts with regard to its validity. Surely the membranous tissue of many plants assuming a green colour has nothing in it of a yellow. But wherever we turn to look for an explication there is doubt; and the solution of the problem may be said to be a chemical puzzle. One attributes it to the presence of an oxide of iron; another to the predominance of an alkali, and neither solution is satisfactory. Yet plants placed in the dark do not lose their green colour, if the atmosphere in which they grow contains a certain quantity of hydrogen or of azote. Humboldt found the leaves of *Poa annua* and *Plantago lanceolata* still green though growing in the galleries of the mines of Freyberg. It should be recollected, however, that they must have been occasionally exposed to the light of the miners' lamps. Leaves, bractes, calyxes, ovaries, are the organs that are most generally green: though you may find exceptions to the rule, both in organs which it includes and in organs which it excludes. The bractes of *Bartsia coccinea* are scarlet, and the embryo of the Mistletoe is green.

III. Though leaves in a healthy state assume for the most part a

green colour, yet they do not always retain that colour so long as they may be said to live. In the autumn they change to yellow, with the exception of the leaves of Evergreens, which retain their green colour till the spring. M. Macaire regards this change of colour as originating in a higher degree of oxidation, owing to the diminished exhalation of oxygen gas in the day, and its increased absorption in the night. The first degree gives yellow; a second degree gives red. This explanation Decandolle seems willing to receive, believing that the *chromule* of the cells is thus capable of assuming all manner of tints, especially if aided by the presence of acids or alkalies.

Changes similar to those resulting from age may occur merely from accident, as from the puncture of insects, the growth of parasitic fungi, or the blighting influence of frost. First they change to yellow; then they change to red.

But some leaves present naturally a different colour on each surface. The upper surface of the leaf of the Cyclamen is green; the under surface is red: yet the red chromule, in this case, exhibits the same chemical properties as the chromule that has been changed to red as the result of age. [Macaire.]

What has been said of leaves with regard to colour may be said of flowers also,—particularly upon the presumption that flowers are nothing more than a mere modification of leaves. It follows therefore irresistibly, that all varieties of colour in flowers or their parts, are owing to the different degrees of the oxidation of their chromule, except in special cases determined by the presence of acids, or of alkalies in a free state.

M. Decandolle refers to a *memoire* of M. M. Schubler and Funk on the colours of flowers, which they divide into two grand series corresponding to the two grand types of vegetable colour—yellow passing into red and white, but never into blue; and blue passing into red and white, but never into yellow. The former they call oxidated colours, the latter de-oxidated colours—Green being the point of equilibrium between the two series. In the process of oxidation you have yellow-green, yellow, orange-yellow, orange, orange-red, red. In the process of de-oxidation you have green-blue, blue, violet-blue, violet, violet-red, red. To avoid the hypothesis of oxidation and de-oxidation, Decandolle denominates the two series the *xanthique* and *cyanique*, indicative merely of the blue and yellow types. In the xanthic series we find *cactus*, *mesembryanthemum*, *aloe*, *cytissus*, *oxalis*, *rosa*, *verbascum*, &c. &c. In the cyanic series we find *campanula*, *phlox*, *epilobium*, *vinca*, *scilla*, *hyacinthus*, &c. &c.

White is excluded from either series, because it is thought to be doubtful whether it exists naturally in a pure state among vegetables.

We do not see the ground of all this distrust. Why is not white to be called white? Surely the corolla of *Lilium candidum* is a very good example of the colour in question. The following changes of colour in quick succession are worthy of notice. The flower of *Hibiscus mutabilis* bursts open its integuments in the morning. Its corolla is then white; at mid-day it is flesh-coloured; at sun-set it is red.

Black is also excluded with more apparent propriety, and yet it is to be found in the petals of some few flowers. *Pelargonium tricolor* and *Vicia Faba* will furnish examples.

The infusion of vegetable reds in alcohol takes a deeper tinge by the addition of an acid, but gives no uniform result by the addition of an alkali. The infusion of vegetable yellows is discoloured by the addition of an acid, but rendered more intense by the addition of an alkali. The infusion of vegetable blues is rendered red by the addition of acids, and green by the addition of alkalies—furnishing the well-known chemical test.

From what has been said, it follows, according to Decandolle, that the modifications of the *chromule*, occasioned by the degree of its oxidation, are the cause of the diversity of colours in the appendages of plants at least—that is, in the leaves, or modifications of leaves, whether spathe, bracte, calyx, or corolla. The degree of oxidation proper to leaves produces green; a higher degree leads to yellow and red; a lower degree to blue. The remainder of this section is devoted to the colour of the several parts of the axis of the plant, as well as of the sexual organs; but we have not room for even the briefest sketch of it.

IV. The brilliancy of the colouring of vegetables, lovely though it be, soon begins to fade, by disease, or by accident, or by death; and plants are often stripped of their colours by the operation of the same agents through which they originally acquired them. The action of solar light, when too intense, destroys the very colour which it had but just generated. Hence the experienced florist places his gaudy but delicate tulips under shelter, knowing that the direct action of the sun's rays would speedily impair their beauty.

The colour of the greater part of the aquatics undergoes a decided change at their death. The *Fuci* in particular, when exposed to the action of the atmosphere, pass from a fine red, or from a fine green, to a dull and dirty white. The *Characeæ* undergo a similar change, owing, as Decandolle thinks, to some change in the composition of their chromule, or to the great quantity of calcareous matter incorporated in their tissue. Leaves in dying assume, for the most part, that brown or russet colour known by the name of *feuille morte*. It

is owing to a change in the composition of their primary principles, accompanied with loss of water. The same explication applies to fruits. The bark of trees in decay changes to a grey, or russet, or dingy white, occasioned by the joint operation of light, of oxygen, and loss of moisture; and even the indurated wood composing the interior of the stem, when cut up and exposed to the action of the sun and air, shrinks, and changes to a deeper shade, which it owes to the operation of the same causes.

COLUMN.—Within the urn or capsule of the mosses, and in the direction of its longitudinal axis, there is situated a slender and cylindrical substance which seems to be a prolongation of the pedicle. This organ is denominated the column, and its summit, which surmounts the urn, was regarded by Hedwig as the style of the mosses.

COMPOSITE ORGANS.—Vegetable organs, which are resolvable immediately into organs deemed elementary, and which may be regarded as exhibiting the first degree of complexity, are said to be compound or composite. The ligneous and the cortical layers, the pith and the epidermis, are examples.

COMPOUND FLOWERS.—"Flowers containing several florets, enclosed in a common perianth, and on a common receptacle, with the anthers connected in a cylinder, as in the Linnæan class Syngenesia, are said to be compound." [Martyn's Lang. of Bot.]

CONCENTRIC LAYERS.—The concentric layers of the vegetable structure are peculiar to plants of exogenous growth, and are either cortical or ligneous.

First, The cortical and concentric layers, or layers constituting the mass of the bark, are situated immediately under the cellular integument, where such integument exists, and where not, immediately under the epidermis, or they are themselves external. They are distinguishable chiefly in the bark of woody plants, but particularly in that of the Lime-tree, in which they are easily separated by maceration, or exposure to the weather, and in which you may readily count a dozen, or more, in a branch or trunk of any considerable size.

In aged trunks, the outer layers are coarse and loose in their texture, exhibiting individually a considerably indurated, but very irregular net-work, composed of bundles of longitudinal fibres, not ascending the stem directly, but winding more or less around the axis of the plant. As the layers recede from the circumference, the net-work which they form is finer, though still very irregular, and their texture more compact. Yet the meshes of the several layers often correspond, and form, at least in aged trunks, pyramidal apertures, or widen into large gaps or chinks, as in the trunk of the Oak or Elm, exhibiting still the rough traces of the original net-work. In young

trees or shoots the apertures formed by the coincidence of the meshes are not yet left empty, but are occupied by a pulp somewhat compressed, which traverses the longitudinal fibres, and binds and cements them together.

In all trunks, the inner layers are soft, smooth, and flexible, and capable of subdivision till reduced to an absolute film, but not always exhibiting a conspicuous net-work. The innermost layer is denominated the *liber*—the Latin name for a book, from its having been used by the ancients to write on, before the invention of paper. It is the finest and most delicate of the layers, and is often most beautifully reticulated, as in the case of the liber of *Daphne Lagetto*, remarkable beyond that of all other plants for the beauty and delicacy of its net-work, and soft and flexible as the finest lace. If the cortical layers, while yet young, are accidentally injured, the part destroyed is again regenerated, and the wound healed up without a scar; but if the wound extends beyond the liber, the part destroyed is no longer regenerated.

Secondly, The ligneous and concentric layers which constitute the great mass of the wood may be seen on the surface of the horizontal section of almost any trunk or branch, as on that of the Oak or Elm, particularly after being for some time exposed to the weather. They have been believed to be equal in number to the years of the plant's growth; but they are not literally or strictly so, neither are they literally or strictly concentric. On the one side or on the other there is generally an excess of width as well as of number, not according as it is exposed to, or sheltered from, the light and heat of the sun, as some writers have affirmed, but according to the accidental situation of the great roots and branches. [Phys. des Arb. liv. i.] The inner layers are the hardest, and the outer layers the softest, and the outermost layer, which is the softest of all, is designated by the peculiar appellation of the *alburnum*, till, in the process of vegetation, it becomes an inner layer in its turn, more solid and more condensed, and is ultimately converted into perfect wood.

How are we to account for the annual formation of the concentric layers? With a view to solve this question, the earlier botanists offered a variety of conjectures. Malpighi was of opinion that the new and annual layer of wood was merely what had been the liber of the former year now converted into alburnum. Grew thought that the annual increment was a production issuing from the liber, and splitting afterwards into two portions, the one a new liber, and the other a new alburnum. Linnæus thought that the new layer of wood was formed from the pith—a supposition that will not bear the test of examination. A very general opinion was, that the new layers were

formed from a substance oozing out of the bark and wood respectively, first a limpid fluid, then a viscid pulp, and then a thin layer attaching itself to the layer that preceded it. But Duhamel showed very plainly that the new and additional layers are not formed from the wood. His first proof was drawn from the experiment of the grafting of a peach on a plum-tree, *par l'ecusson*. At the end of four or five months after the insertion of the graft, a portion of the stem including the graft was cut off, when there was found under the escutcheon a thin plate of the wood of the peach, united to the former by its edges, but not by its inner surface. His second proof was drawn from the experiment that follows:—Having detached a ring of bark from its trunk, and covered the wood below it with a thin plate of tin-foil, he then replaced the bark as before, and reduced the case to the following dilemma: If the new layer of wood is formed from the old layer of wood, then it is plain that the new layer will be deposited within the tin-foil; and if it is formed from the old layer of bark, then it is equally plain that it will be deposited without the tin-foil. The result was, that a new layer of wood was deposited between the bark and the tin-foil, but none between the tin-foil and alburnum. Hence Duhamel concluded that the new layer of wood is formed from the liber through means of a mucilage or *cambium*.

Although the above deduction is perfectly legitimate, yet it raises the following question:—Is the bark to be regarded as the generating cause of the new layer, or merely as the medium of the transmission of the materials out of which the new layers are formed? The solution of this question was reserved for Mr. Knight, who has shown by the most satisfactory evidence that the sap is elaborated, so as to render it fit for the formation of new parts, in the leaf only. If a leaf or branch of the vine is grafted even on the fruit-stalk or tendril, the graft will still succeed. [Phil. Trans. 1803.] But if the upper part of a branch is stripped of its leaves, the bark will wither as far as it is stripped; and if a portion of bark furnished with a leaf is insulated, by means of detaching a ring of bark above and below it, the wood of the insulated portion that is above the leaf is not augmented. [Phil. Trans. 1801.] This shows evidently that it is the leaf which gives the elaboration of the sap that is necessary to the formation of new parts, and that, without the agency of the leaf, no new part is generated. The fact then is, that the new layer is formed not absolutely from the bark, as the experiments of Duhamel might seem to indicate, but from the elaborated sap descending through the returning vessels of the leaf, leaf-stalk, and inner bark, from the summit to the root of the plant. [See CHANNEL OF THE CAMBIUM'S DESCENT.]

This is conformable to the doctrine of M. Dutrochet, who regards

the new layer as being formed partly from the bark and partly from the wood, by means of the horizontal adfluxion of the descending and elaborated sap through the medium of the cells of the divergent layers ; because trees felled in winter, and left with their bark entire, will still have an effusion of elaborated juice in the spring, between the bark and wood, and will still protrude buds and slender shoots, and form a new layer, which cannot, as he thinks, have any other source than that of the juice already lodged in the wood and bark, and which is now propelled to its destined station by the action of the divergent layers. This opinion he regards as being further sanctioned by the fact, that increase by annual and concentric layers is no where to be met with except among plants furnished with divergent layers. [L'Agent Immed. 47.]

Still there remains a hypothesis on this subject which deserves our notice. It is that of M. Du Petit Thouars, a sound botanist, but not a very successful theorist. According to him, the new layers that are annually added to the plant, are not formed from a cambium that has been elaborated in the leaf, but from the axillary buds only, which, like the seeds, emit roots that descend between the wood and bark till they reach the lower extremities of the plant, being nourished by the cambium, but not originating in it. Upon this principle a plant is merely a congeries of buds or of fixed embryos, elongating partly upwards to form new branches, and partly downwards to form new roots, which, coalescing in their descent, constitute the new layers of wood and of bark. Indeed, so far are leaves from nourishing a plant, that to strip a tree of its leaves, according to M. Du Petit Thouars, would be the means of increasing its diameter ; so that plants seem to have had leaves given them rather for show than for service, and would doubtless be better off without them. Yet this theory, extravagant as it is, Dr. Lindley lauds as the only one that accounts satisfactorily for all the phenomena of vegetable augmentation, and represents the arguments of those who oppose it as founded in fallacies. [Introd. to Bot. 245.] But if the root of the bud is so analogous to the radicle of the embryo, how is it that it is content to ascend in the pendent shoot, while the radicle will ascend in no case whatever ? We ask, also, with Decandolle, how it is that the evolution of the leaves and the flowing of the cambium are so uniformly simultaneous, if the latter is not derived from the former ? Or how is it that the formation of layers will still go on if you deprive a tree of its buds, but will not go on if you deprive it of its leaves ? The argument against this theory arising from the graft is not yet well answered, and much propping is still wanted to make the theory good.

Let us look a little at the case of the graft; and let it be that of a white graft upon a red stock. A bud from the graft sends down its root till it reaches the stock. So far it continues white; but no sooner does it pass the graft than it becomes red; because, as the advocates of the root-system say, it now receives its nourishment from the juices of the red stock by lateral adfluxion. But why are the cells of this internal root to receive that nourishment merely as repositories? Why are they to be deprived of the power of assimilation, which every other cell of every other organ possesses, selecting what is best suited to its wants, and producing its own type, as the cells of the divergent layers of the stock are already supposed to have done? Still, if the colour were the only thing that is altered, the change would be but trifling, and we might allow it to pass without notice. But this is not all; the very character of the root itself is altered, the nourishment having been made to assimilate the organ, and not the organ to assimilate the nourishment; which led M. Decandolle to say that M. Du Petit Thouars' phytology was bad. It was evidently not quite consistent; and if we examine Dr. Lindley's alleged fallacies, we shall find that there is no fallacy in them after all; and that the doctrine of the root-theory of M. Du Petit Thouars is very far from being yet established.

CONDITIONS OF GERMINATION.—The conditions of germination relate either to the internal state of the seed itself, or to the circumstances in which it may be placed, with regard to surrounding substances. In my "System of Physiological Botany," published in 1816 [vol. ii. 3], I enumerated five conditions as being necessary to the process of germination, and I still adhere to that statement, though its accuracy has been impugned by a great botanist.

I. The first condition necessary to germination is the maturity of the seed. This fact M. Decandolle denies,—saying that "*M. Keith ne s'est pas exprimé avec précision lorsqu'il a posé la maturité de la graine pour première condition générale et nécessaire à la germination;*" and adding that Senebier and Treviranus succeeded in making green peas to germinate a short time before they were absolutely ripe. [Phys. Veg. ii. 662.] If M. Decandolle had read to the end of the paragraph which he criticises, he would have seen that the identical exception which he specifies is mentioned by Mr. Keith. He would have seen also, that radish seed, which M. Lefébure could not prevail upon to germinate till it was quite ripe, will germinate, when it pleases, before that period arrives. If left long upon the stalk in a wet season, it will germinate even in the pod. Also lemon-seed will sometimes germinate in the very centre of its pulpy pericarp, even before the fruit is cut open. After all, we regard these apparent exceptions as

amounting absolutely to nothing. The seeds were not ripe, it is true, in the common acceptation of the term, which supposes them to be as dry and as hard as a bone; but they were ripe in the physiological acceptation of it, and that is enough. The seed that will germinate is, physiologically speaking, ripe—that is, its fluids have been so elaborated in the process of its maturation, and its solids so vitalized in the assimilation of due aliment, as to be already duly susceptible to the action of the combined *stimuli* of the soil and atmosphere. Hence the maturity of the seed is legitimately and rightly placed by Mr. Keith in the list of the conditions of germination, and the objection of M. Decandolle altogether frivolous.

II. The second condition necessary to germination, or at least to rapid and healthy germination, is the exclusion of light. The practice of the harrowing or raking in of the grains or seeds, sown by the farmer or gardener, is founded upon this principle. But it does not seem to have engaged the notice of men of science, or to have been proved by direct and intentional experiment, till lately. The first direct experiments that were instituted on this subject are those of Ingenhouz. He found that seeds germinate faster in the shade than in the sun, and hence concluded that light is prejudicial to germination. Senebier, who afterwards repeated the experiments of Ingenhouz, drew from them the same conclusion. [Mem. Phys. Chim. vol. iii. 341.]

It has been thought by chemists of eminence, that the injurious effect of light is owing to its action on the carbonic acid gas contained in the seed, by which its oxygen is withdrawn too rapidly, its carbon fixed, its mass parched, and the possibility of its germination thus precluded. Yet in the face both of the above facts and opinions M. Decandolle denies that the exclusion of light is a necessary condition of germination, alleging that he has known seeds to germinate though left exposed to the action of the direct rays of the sun. I care not for what may have taken place in M. Decandolle's study, or laboratory, or for what every body is said to know. I only ask whether it would be prudent in the farmer or gardener to adopt a practice founded on the principle here advocated, and to sow his seeds without screening them from the light?

III. A third condition necessary to germination is the access of heat. No seed has ever been known to germinate at or below the freezing point. Hence seeds do not germinate in winter, even though lodged in their proper soil. Yet the potential vitality of the seed is not necessarily destroyed by this exposure; for the seed will germinate still, on the return of spring, when the ground has been again thawed, and the temperature raised to the proper degree.

IV. A fourth condition necessary to germination is access of mois-

ture. Seeds will not germinate if they are kept perfectly dry. Water therefore, or some liquid equivalent to it, is essential to germination. Hence rain is always acceptable to the farmer or gardener immediately after he has sown his seeds; and if no rain falls, recourse must be had, if possible, to artificial watering. But the quantity of water applied is not a matter of indifference. There may be too little, or there may be too much. If there is too little, the seed dies for lack of moisture; if there is too much, the seed rots.

V. A fifth condition necessary to germination is the access of atmospheric air. Seeds will not germinate if placed in a *vacuum*. Ray introduced some Lettuce seeds into the receiver of an air-pump which he then exhausted, but the seeds did not germinate. Yet they germinated upon the re-admission of the air, which is proved by consequence to be necessary to their germination. Whether the whole of the ingredients of the atmospheric air is necessary, or only part of them, will appear under the head of the CHEMICAL PHENOMENA OF GERMINATION.

Such are the five conditions which we represented as necessary to successful germination, and still we adhere to the correctness of our list, notwithstanding all that M. Decandolle has written about the germinating of immature seeds, or the non-necessity of the exclusion of light. But what says old Evelyn on the subject of the two disavowed conditions? “Choose your seed of that which is *perfectly mature, ponderous and sound*.” [Sylva, chap. i. sect. 2.] “Keep your newly sown seeds continually fresh, and *in the shade*, as much as may be, till they peep.” [Ibid. chap. xxxii. sect. 2.] These are maxims resulting from long and personal experience, whether in farming or in gardening, with which the experience of the study or laboratory, in the present case beyond all others, is not fit to be compared.

CONNECTIVUM.—The organ that unites the two cells of the anther is denominated the *connectivum*. Still it does not so often present itself under the aspect of a distinct organ, as under that of a process issuing from the stamen;—tapering to a point and terminating at the apex of the anther, as in *Lilium candidum*; or assuming the form of a large lobe on which the anther rests, as in *Lamium purpureum*, or of a petaloid expansion, outskirting and overtopping the anther, as in *Glossarrhen floribundus*. [Von Martius. Lindley.]

CONSERVATIVE ORGANS.—Organs whose functions regard merely the growth and health of the plant, as opposed to those which regard the reproduction of the species, are by some phytologists denominated conservative organs. Mr. Burnett calls them *nutrients*.

CONSUMPTION.—From barren or improper soil, unfavourable climate, careless planting, or too frequent flowering, which exhausts the

strength of the plant, a diseased state of the organs is often induced, with a gradual wasting away of the vitality, which terminates ultimately in the death of the individual. It is with sufficient propriety denominated consumption. The Pine-tree is liable to an affection of this sort that is known by the name of *Teredo pinorum*. [Willd. Prin. 351.]

CONTORTION.—The leaves of plants are often injured by means of the puncture of insects, particularly of the genus *aphis*, so as to induce a sort of disease that discovers itself in the irregular convolution of the margin of the leaf punctured, or in the wrinkled aspect of its upper surface. This is the disease called contortion. The leaves of the Apricot, Peach, and Nectarine, are extremely liable to it in the months of June and July. The punctured leaf assumes a wrinkled, reddish, and scrofulous appearance. The margins roll inwards on the under side, and enclose the eggs of the noxious little animal, the hatching of which can be prevented only by the stripping off of the diseased leaves.

CORMUS.—That portion of a bulb, having the figure of a flattened disk, or of a depressed cone, which remains with the radical fibres attached to it or protruding from it, after the coats or scales have been stripped off, is, by most of our modern botanists, denominated a *cormus*. It is equivalent to the *Plateau* of M. Decandolle, and is all that many bulbous plants have to show for a stem. Dr. Lindley restricts its application to what has been called a *solid bulb*, which appellation he would discard entirely from the language of botany.

CORK.—The outer and exfoliated bark of *Quercus Suber*, a species of oak that grows in great abundance in the south of France, Spain, and Italy, is the substance known in commerce by the name of cork.

COROLLA.—The corolla is the interior envelope of the flower,—that is, where two envelopes are present,—investing the central parts, and invested by the calyx. It is generally of a finer and more delicate texture than the calyx, and is of all the parts of the fructification the most showy and ornamental,—being always, or with few exceptions, that which is the most highly coloured, as well as that from which the flower imparts its rich and fragrant perfumes—its *croceos odores*—delighting at the same time both the sight and smell. To this most elegant part of the fructification, the term corolla has been very happily applied by Linnæus, signifying, as it does in the original, a crown or chaplet of flowers.

“Et modo solvebam nostra de fronte corollas.”—PROPERT. i. 5. 21.

Like the calyx, the corolla consists either of a single piece called a petal, or of several distinct pieces called petals. In the former case it is monopetalous, or tetrapetalous, according to the number of distinct

petals. The monopetalous corolla is regarded as divisible into three parts—the tube, the mouth, the border. The tube is the lower portion, cylindrical and inflated. The mouth is the middle portion, often beset with fine hairs, or with small projecting scales, so as nearly to shut it up. The border is the upper and expanding extremity. In its general contour, it is bell-shaped, or club-shaped, or funnel-shaped, or wheel-shaped. In the polypetalous corolla, each petal is regarded as divisible into a claw and a border, the aggregate contour assumes many forms—the cruciform, the rose-like, the papilionaceous. Like the calyx, the corolla is not to be regarded as absolutely essential to the botanical notion of a flower, because in some flowers it is altogether wanting. Yet where one only of the two envelopes is present, it is sometimes a matter of considerable difficulty to say which of them it is. Botanists have laid down several rules on this subject, but no one that it is quite satisfactory. In cases of doubt it will be well to take analogy for our guide, though the difficulty may certainly be evaded by calling the envelope when single a Perianth, whether calyx or corolla.

COTYLEDONS.—The cotyledons or seed-lobes are appendages of the embryo, enclosing or accompanying the tender plantlet, and containing its first nutriment. In germination they either lie buried in the earth, as in the case of the Horse-chestnut, and are hence called *hypogæan*; or they spring up into the air, as in the case of the radish, and are hence called *epigæan*. In this last case they are converted into a seminal leaf if the lobe is solitary, or into seminal leaves if there are more lobes than one. Upon the principle of the presence or absence of cotyledons, we have the grand and primary division of plants that are cotyledonous on the one hand, and plants that are acotyledonous on the other; as well as of the subordinate divisions of monocotyledonous, dicotyledonous, and polycotyledonous plants also. These distinctions are deemed to be the true key to a natural system, and form the basis of the arrangements of Jussieu.

CRUCIFORM FLOWERS.—If the petals of a tetrapetalous corolla are so disposed on their receptacle as to spread out in the form of a cross, they are said to be cruciform. Plants having flowers of this form constitute the fifth class of Tournefort's system, and a prominent portion of the class Tetradynamia of Linnæus.

CORYMB.—A species of inflorescence in which the peduncles issue at different points of a common and longitudinal axis; but the lower ones being longer, the flowers still exhibit a flat and level surface, as in *Pyrus aucuparia*.

CRYPTOGAMOUS PLANTS.—Plants whose organs of fructification are not visible except through the aid of glasses are said to be cryptoga-

mous. They constitute the last class of the system of Linnæus, and the first of the system of Jussieu; the cryptogamia of the former, the acotyledones of the latter.

CULM.—The stalk or stem of the grasses is the culm of botanists. It is jointed and hollow, as in wheat and oats; or without joints, but containing a pith, as in *Juncus effusus*.

CUPS AND SAUCERS.—On the *thalli* or fronds of the Lichens there are generally to be found certain organs containing a powdery substance analogous to the pollen, or to the seeds of perfect plants. These organs, from the forms which they assume, have been called by various names,—shields, targets, warts, tubercles; or, more vulgarly, cups and saucers.

CURTAIN OR VEIL.—Of the cap-bearing fungi the greater part are furnished with a fine, delicate, and cobweb-looking membrane called the veil, or curtain, attached on the one hand to the circumference of the pileus, and on the other to the circumference of the stem, enclosing and protecting the gills. It may be very distinctly seen in the Common Mushroom at an early period of its growth.

CYME.—The cyme or tuft is a species of inflorescence somewhat resembling the umbel, as in *Viburnum Opulus*.

DECAY AND DEATH OF THE PLANT.—Every one who has studied the phenomena of vegetation must have seen that plants are liable to a variety of maladies, arising from external injury or from internal derangement. But though a plant should be lucky enough to escape this general contingency, and should not suffer perceptibly whether from wound or from disease, still a time will come when it will begin to experience the approaches of a natural decline insensibly stealing upon it, and at last inducing death. For in the vegetable as well as in the animal kingdom, there is a term or limit set, beyond which the individual cannot pass, though the duration of vegetable life is very different in different species.

Some plants are annuals, and last for one season only, springing up suddenly from seed, attaining rapidly to maturity, producing and again sowing their seeds, and perishing immediately after,—the poppy, the sun-flower, mignonette. Some continue to live for a period of two years, and are hence called biennials, springing up the first year from seed, and producing root and leaves, but no fruit; and in the second year producing both flower and fruit, and then perishing,—carraway, the carrot, the parsnip. Others are perennials, that is, lasting for many years, of which some are under-shrubs, and die down to the root every year, as the Raspberry; others are shrubs, and are permanent both by root and stem, but without attaining to a

great height or to a great age, as the Lilac ; and lastly, others are trees, permanent both by root and stem, as well as attaining to a great size and living to a great age, as the Oak. But even of plants that are woody and perennial there are parts which perish annually, or which are at least annually separated from the permanent mass, as the leaves, the flowers, the fruit ; leaving nothing behind but the bare caudex, which submits in its turn to the ravages of time, and ultimately to death—

“ Tempus edax rerum, tuque invidiosa vetustas,
Omnia destruitis.”

OVID. MET. Lib. xv. 234.

Thus we have, first, the decay of the temporary organs ; and, secondly, the decay of the permanent organs.

I. The decay of the temporary organs, which takes place annually, is a phenomenon familiar to every body, and comprehends the fall of the leaf, the fall of the flower, and the fall of the fruit.

The fall of the leaf, or annual defoliation of the plant, commences, for the most part, with the frosts of autumn, and is accelerated by the cold winds of winter, that strip the forest of its foliage, and the landscape of its verdure. Yet there are trees that retain their leaves throughout the whole of the year, though changed to a dull and dusky brown, as those of the Beech-tree ; and there are others that retain them in verdure even till the succeeding spring, when they ultimately fall. Such plants are denominated Evergreens, and have been vulgarly supposed never to shed their leaves at all,—an error originating, as we may believe, in the fact of their not shedding them till the young leaves have begun to appear, as in the case of *Lauro-cerasus*, or Common Laurel. In warm climates there are many plants that retain their leaves even for several years ; but in temperate and polar climates there are no such plants to be found. African trees at the Cape do not shed their leaves in the winter ; but trees imported from Europe continue to shed them as before. [Thunberg's Trav. i. 104.]

The fall of the flower is not, like the fall of the leaf, dependent upon the approach of winter. It takes place at any season, and at all seasons, of the year, when the object of its production has been effected ; and as the impregnation of the germ is the object of its production, that impregnation is no sooner achieved than the flower begins to give indications of decay ; so that the most beautiful part of the vegetable is also the most transient. Thus the flower of the night-blowing *Cereus*, *Cereus grandiflorus*, so impatient of the light of day, no sooner unfolds its magnificent petal than it begins to fade ; and, before the sun has risen upon it, its beauty is gone. The flowers of the poppy and tulip, as well as of the lovely rose, though very

sweet or gaudy, are yet very short-lived; and the beautiful blossom of our fruit-trees expands but to wither and decay. The scene often continues blooming, indeed, in the landscape both of nature and of art, but that is more owing to the succession of blossoms, on the same or on different plants, than to the permanency of individual flowers, which are protruded but to fall. Yet even in their fall they are lovely. Who that has read, has not admired, Petrarcha's inimitable description of the shower of flowers or of blossoms that fell into the bosom and lap, and about the person, of Laura, as she sat by the side of a fountain, under a flowering tree?

“ Da' be' rami scendea—
 (Dolce nella memoria),
 Una pioggia di fior sovra 'l suo grembo ;
 Ed ella si sedea
 Umile in tanta gloria
 Couverta gia dell' amoroso nembo.
 Qual fior cadea sul lembo,
 Qual su le trecce bionde,
 Che oro forbito e perle
 Eran quel di a vederle ;
 Qual si posava in terra, e qual su l'onde
 Qual con un vago errore
 Girando pareva dir, ‘ *Qui regna Amore.* ’ ”

Canzone xiv. Zotti.

“ From these fair boughs the wind,—
 How well I call to mind !—
 Shook down upon her bosom flower on flower ;
 And there she sat meek-eyed,
 Humble in all the pride
 Of blossoms scattering soft their amorous shower.
 Some to her hair paid dower,
 And seemed her golden curls
 Queen-like to deck with pearls ;
 Some snowing on her drapery stopped,
 Some on the earth, some on the water dropped,
 While others, fluttering from above,
 Seemed wheeling round in pomp, and saying ‘ Here reigns love ! ’ ”

LEIGH HUNT'S POEMS.

The fall of the fruit does not suddenly succeed the fall of the flower. But when the flower falls, the fruit, which is still diminutive, begins to expand rapidly in volume, assuming a peculiar hue as it ripens, as well as a peculiar flavour, till it reaches its full maturity, when it ultimately detaches itself from the plant and drops into the soil. Yet it does not in all cases detach itself in the same manner. In the bean and pea the seed-vessel opens and lets the seed fall out. In the apple and cherry the fruit falls entire, enclosing the seed, which escapes

when the pericarp decays. Most fruits fall soon after ripening, as the peach and apricot, if not gathered ; but some remain long attached to the parent plant after being fully ripe, as in the case of that of *Evonymus*, which may be seen in the hedges in the midst of winter, and of *Mespilus*, which continues till the succeeding spring. But these, though tenacious of their hold, detach themselves at last, as well as others, and bury themselves in the soil, about to give birth to a new individual, in the germination of the contained seed.

Such is the fact of the annual fall of the temporary organs : how is it accounted for ? Duhamel accounted for the fall of the leaf as follows. When the sap begins to flow less plentifully, the leaves, to whose vigour a great supply is necessary, soon become stiff and rigid, and hence less fit to discharge their functions duly. But it is known that the branches grow in thickness after they have ceased to grow in length, which tends to dis sever the fibres of the footstalk and stem at the point of articulation, and hence the leaf loses its hold. This explication is plausible, but not altogether satisfactory ; for it may be doubted whether it is at all applicable to the case of Evergreens, or of plants indigenous to warm climates, which retain their leaves for several years. Hence other explications have been offered to supply its place. The phenomenon was regarded by Vorlick as being analogous to that of the process of sloughing in the animal economy ; and to this opinion Mr. Lindley subscribes. [Intro. 249.] Yet the analogy does not seem to be very well made out. Sloughing in the animal economy is that power, or the exertion of that power, by which the living body is capable of throwing off a part that has accidentally become diseased, or unfit for discharging the functions for which it was originally intended,—which it does by forming beneath the slough, a new part precisely similar in character to what the slough originally was, and fitted to supply its place. But this is not the case in the fall of the leaf, which always separates from the plant in a determinate manner, and at a determinate point, namely, at the base of the footstalk, which forms as it were a natural joint or articulation, to which there is nothing analogous in the case of sloughing, as the leaf is not pushed off by the formation of a leaf beneath it. Not that there exists no example whatever of vegetable sloughing ; for the fact of the continual exfoliation of the bark of the Plane-tree affords that example ; but the fall of the leaf does not afford it. Yet if it is necessary to illustrate the fall of the leaf by any analogous process in the animal economy, it may be done by comparing it to that of the shedding of the antlers of the stag, or of the hair or feathers of other beasts or birds, which, being like the leaves of plants, distinct and peculiar organs, fall off and are regenerated annually, but do not slough. Still

it is desirable to trace the *rationale* of the process of the separation of the leaf from the plant, which appears to consist merely in the peculiar change that time effects in the articulation uniting the foot-stalk to the twig or branch, according to the remark of Mr. Fairbairn, who observed that, in the transplanting of trees, if the injury caused by the process is confined merely to the leaf, without affecting the branch, the injured leaves are soon thrown off, or they fall of their own accord; but if the injury extends suddenly beyond the leaf, and affects the branch also, then the leaf remains firmly attached to the plant even though dead. In this last case it is evident that, if the leaf does not fall, it is because the articulation has not been duly prepared, and because the vital energies of the plant can now no longer act upon the point of natural separation in consequence of the intervention of the dead, or diseased, portion of the branch beyond which life has withdrawn itself. But in the natural process of vegetation the necessary change is effected by the leaf on the one hand, in its yielding to the influence of physical or chemical agencies, and withering and shrinking into a narrower compass, when the usual supply of sap is no longer transmitted to it; and by the vital energies on the other, in their controlling and directing of chemical agencies so as to facilitate the final detachment of the foot-stalk, and form the scar necessary to the protection of the plant. In this process the substance that cements the respective fibres of the leaf-stalk and branch together, is converted from a soft and glutinous to a dry and brittle consistence, analogous to the change that takes place in the seams of the valves of ripening capsules or pericarps, so that the leaf falls, at last, merely by force of its own weight, or of the slightest touch of the finger, or of the gentlest breath of wind. The same explication is applicable to the fall of the flower, and also to the fall of the fruit.

II. In the above remarks it has been shown that the temporary organs, the leaves, the flowers, the fruit, fall periodically, while the permanent organs, the *caudex ascendens* and *descendens*, remain to carry on the process of vegetation. But there is a period beyond which even the permanent parts themselves begin to be affected by the infirmities of old age, as in the case of animals, and to exhibit, like them, symptoms of approaching dissolution. The root refuses to imbibe the nourishment presented to it by the soil, or if it does imbibe a portion, it is but feebly propelled, and partially distributed through the tubes of the alburnum. The elaboration of the sap is effected with difficulty, as well as its assimilation when elaborated, or its descent through the wonted channel. The bark becomes thick and woody, and covered with moss or lichens; the shoot stunted and diminutive, and the fruit palpably degenerate both in quantity and

quality. The smaller or terminal branches fade and decay the first, and then the larger branches also, together with the trunk and root. The vital energy of the fabric gradually declines without any chance of recovery, and is at last totally extinguished; while the solid mass of the plant exposed to the chemical action of the surrounding substances, to which it now yields, withers, and dies away, presenting to the eye a decayed and rotten appearance, and crumbling into the dust from which it originally sprang. Such is the transient duration of the vegetable, and counter-part of animal life!

DECOMPOSITE ORGANS.—If compound organs are divisible into component organs which are themselves compound, they are said to be *decomposite*, as exhibiting the highest degree of organic complexity. Thus the root, trunk, and branches are decomposite organs as consisting of bark, wood, and pith, which are themselves compound or composite organs in a lower degree.

DECOMPOSITION OF WATER.—Although the opinion was proved to be groundless, by which water had been supposed to be convertible, by means of the action of the vital energies of the plants, into all the different ingredients found in the composition of the vegetable substance; yet, when water was ultimately proved to be a chemical compound, it was by no means absurd to suppose that plants may possess the power of decomposing part, at least, of what they absorb by the root, and thus acquire the hydrogen as well as a portion of the oxygen which by analysis they are found to contain. This opinion was pretty generally adopted, and was thought by Senebier to receive support from the fact of the germination of some seeds which were moistened merely with water, and without having any apparent contact with oxygen. But to this it was objected by M. Theod. de Saussure, that the seeds in question might have germinated in consequence, not of the decomposition of water, but of the action of the air which the water contained. Its decomposition was also inferred by Ingenhoutz, from the fact of the amelioration of an atmosphere of common air into which he had introduced some succulent plants vegetating in pure water. But as the degree of amelioration was not stated, Saussure regarded the fact as inconclusive. The decomposition in question was next inferred from the discovery of the fact that plants vegetating in pure water augment their weight, at least in a green state, even though confined in an atmosphere of oxygen, or of common air deprived of its carbonic acid. Yet this fact is inconclusive also; as it might have been owing merely to the introduction of water into the vegetable cells or vessels, in more than a due degree subject to expulsion by drying. Hence, it was now seen that the only evidence by which the question could be determined was that of the augmentation of the solid substance of the vegetable in a dried state.

With a view to attain that evidence Saussure instituted a variety of experiments, of which the following is the most favourable to the doctrine of the decomposition of water. Seven plants of *Vinca minor*, which were made to vegetate in pure water in a receiver filled with common air and carbonic acid gas, assimilated, in the space of six days, the carbon contained in $21\frac{3}{4}$ cubic inches of the mixture, or a quantity equal to 4.2 grains. They assimilated, at the same time, seven cubic inches of oxygen. But as that was replaced by an equal quantity of nitrogen, it goes for nothing in the weight of the plants. Before the experiment they weighed, in their green state, $168\frac{3}{4}$ grains, which were ascertained to be equal to 51 grains of dried vegetable matter. Yet, after the experiment the quantity of dried vegetable matter was found to be equal to 61 grains. There was consequently an augmentation in weight of 10 grains, of which 4.2 only can be attributed to the formation of carbon. Hence, it seems to follow that there had been either a decomposition of water, and an assimilation of its component parts; or, at the least, a fixation of it, by means of which 5.8 grains were added to the weight of the dried plant.

Still there is no proof that plants do in any case decompose water directly—that is, by appropriating its hydrogen, and at the same time disengaging its oxygen in the form of gas. Yet Sir Humphrey Davy was of opinion that they might.—“It appears probable,” says that distinguished chemist, “in some cases, in which oily and resinous bodies are formed in vegetation, water may be decomposed, its oxygen set free, and its hydrogen absorbed.” [Agri. Chem. Lect. v. 202.] M. Decandolle asks whether there may not be examples of decomposition in which the plant shall retain the oxygen, and disengage the hydrogen?—and he finds that such examples exist, at least in the case of some of the plants called cellular. Humboldt was the first to make the discovery. He found that the stipe of *Agaricus campestris*, as well as that of several other species, exhales hydrogen, if put under water, whether in the sun or shade, and the accuracy of the observation has been confirmed both by Decandolle and by other experimenters. In this way then the decomposition of water is direct. But though there is no positive proof of the decomposition of water in plants called vascular, still Decandolle regards it as being very probable that such a decomposition takes place in one or other of the various processes essential to vegetable nutrition, and that its component principles enter individually into the formation of certain vegetable substances—especially such as contain hydrogen, or oxygen in a greater proportion than that in which they exist in water. [Phys. Veg. Tome i. 411.]

DEFINITE INFLORESCENCE.—If the principal axis of the inflorescence

is terminated by a flower-bud, such inflorescence is said to be definite, because there can be no further prolongation of the axis beyond the flower-bud that already crowns it.

DEFINITION OF THE PLANT.—If vegetables are living beings springing from a germ augmentable by nutrition, and susceptible to the action of stimuli, so as to give them in some degree a resemblance to animals, how are we certainly to distinguish the latter from the former? At the upper extremes of the two kingdoms the distinction is easy. The more perfect animals can never be mistaken for plants, nor the more perfect plants for animals. But at the lower extremes where the two kingdoms may be supposed to unite, the shades of discrimination are so very faint, or evanescent, that of some individual productions it is almost impossible to say to which of the kingdoms they belong. Hence it is that substances which have, at one time, been classed among plants have, at another time, been classed among animals; and at this very day there are still cases of doubt. The claim of the Zoologist to the singular genus of the *Oscillatorias*, seems to be about as good as that of the botanist.

The definitions of the earlier botanists were very inaccurate. One of the ancients defined a plant to be an animal fixed by means of a root. But this definition is good for nothing, for it requires the assistance of at least two others to make it good—one for the term animal, and another for the term root; and if when you come to the term animal, you proceed upon the same principle, you must then say that it is a wandering plant which has no root to fix it; so that thus you define your terms in a circle and explain nothing.

Jungius, a botanist who flourished about the beginning of the seventeenth century, defined a plant to be a body possessing vitality, but without sensation, and fixed to a certain spot from which it derives the nourishment necessary to the developement of its parts, and reproduction of the species. [*Isag. Phytosc. cap. i.*] This definition is, no doubt, a great improvement upon the former; but it cannot be said to be by any means correct; for it is very well known that all vegetables are not confined to a particular spot, and that such as are so confined do not always derive their nourishment from that spot. Many of the aquatics, even in their vegetating state, are wafted on the surface of the water by means of the winds, or impelled by the action of the waves; and many of the Lichens and Algæ are attached even to the solid rock.

Linnæus, the great reformer of natural history, and chief of all botanists, undertook, as well became him, to define the boundaries of the mineral, vegetable, and animal kingdoms. His definition is as follows:—“*Lapides crescunt; vegetabilia crescunt, et vivunt; animalia*

crescunt, vivunt, et sentiunt.” [Phil. Bot. p. 1.] “Stones grow, plants grow and live, animals grow, live, and feel.” This definition is extremely plausible, and bears upon the face of it the genuine stamp of the bold and masterly manner of Linnæus. But with all due deference to that great naturalist, still his definition must be regarded as defective. For, in the first place, stones do not grow in the sense in which plants and animals grow; and in the next place, as we are possessed of no criterion by which we may infallibly judge of the existence of the faculty of sensation, the difficulty of decision remains as before. For if the naturalist should happen to meet with an animal which does not exhibit what he might be inclined to regard as a satisfactory evidence of sensation, he must of necessity place it in the class of vegetables, while, at the same time, it still remains an animal.

M. Bonnet of Geneva defined the plant to be an organized body nourished by means of roots placed externally; the animal being just the converse—that is, an organized body nourished by means of roots placed internally—the lacteals of the animal system. [Consid. sur les Corps Organ.] This definition is sufficiently applicable to the generality of cases, but it fails just where the foregoing definitions have been found to fail,—that is, in cases which are really doubtful;—and if this criterion is the only true test of distinction between the animal and vegetable, then all animals whatever, before they are protruded from the egg or womb, are to be regarded as plants, because they are then nourished by means of an *umbilicus*, which we cannot but regard as an external root.

Dissatisfied with all previous distinctions, and qualified, from the depth of his knowledge and extent of his views, to mark and select the most decisive characters of discrimination, the acute and indefatigable Hedwig suggested the following rule, founded, as he thought, on a universal law of vegetable nature, and affording the only incontrovertible test by which the plant is to be discriminated from the animal;—namely, that the reproductive organs, after having discharged their peculiar functions, uniformly decay and drop off before the fruit has reached maturity, while those of the animal remain permanent, and perish only with the individual. [Tracts Rel. to Bot. Lond. 1805.] But if it is true, as Gærtner maintained, that some genera, perhaps even some tribes of plants are destitute of sexual organs altogether, and propagated, not by seeds, but by germs; or if there are either plants or animals whose sexual organs have not yet been detected, as in the case of the Polypi, what after all is the value of the rule?

It has been thought that a line might be drawn dividing the animal from the vegetable kingdom, upon the ground of the character of the food affected by each. Such is, particularly, the opinion of M. Mirbel.

[*Traité d'Anat. et Phys. Veg.*] Plants feed, it is said, upon unorganized substances—earths, salts, water, gases; animals, upon substances already organized—that is, either upon other animals, or upon vegetables, or their products. We do not regard it as a very good or a very correct rule; at any rate, it is too difficult of application. Animals thrive well upon milk alone, which is not an organized substance. If you say that it is the product of an organized being, let it be remembered that it is also a very good food for vegetables. In short, the chief food of plants as well as of animals, is either animal or vegetable substances in a state of solution; and though animals may feed upon substances that are still in an organized state, yet they cannot convert them into nourishment till they have destroyed their organization in the stomach. Is it certain that all animals require a food that has once been organized?—What is the food of *Cancer salinus*, that is found in the salterns at Lymington, frolicking in the midst of the brine, and is never seen but when that solution is in a high state of concentration?—Is it true, or is it not true, that the Chameleon can live upon air; or that leeches, and tadpoles live solely upon water?

Upon the principle of a copious enumeration of particulars, I submit the definitions that follow with a view to mark out the boundaries which separate the three kingdoms of nature.—A mineral is a mass of lifeless matter—inorganic, inert, insentient; not augmentable by nutrition, but attaining its bulk merely by the external and mechanical or chemical apposition of new parts or particles.—A vegetable is a living and organized body, incapable of locomotion, insentient; but springing from, and producing, a germ that is augmentable by nutrition; being usually fixed to the soil, or other appropriate substance of support, by a root or disk, or but very rarely free; and deriving its aliment from the fluids of the medium in which it grows.—An animal is a living and organized being, self-moving, sentient; springing from, and producing, a germ that is augmentable by nutrition, and ranging in quest of aliment, which, with the exception of the *infusoria*, it takes up chiefly in a solid state, and subjects to the action of digestive organs.

There are assignable limits, therefore, that separate the three kingdoms of nature,—between minerals and vegetables, organization; between vegetables and animals, locomotion, digestion, sensation. Under any artificial rule difficulties are likely to occur; for, if nature has not assigned to the animal and vegetable kingdoms respectively any positive and specific limits, but has blended them, as it were, both together, man will institute his distinctions in vain. It is extremely desirable, however, that some criterion should be established, as ge-

neral in its extent and as easy in its application as possible; and for all practical purposes it has been thought that plants may be distinguished from animals with sufficient accuracy by means of the trial of burning; as animal substances in a state of ignition exhale a strong and phosphoric odour, which vegetable substances do not; and undergo a peculiar species of contraction or crispaton, which French physiologists designate by the term *racornissement*.

DEGENERATION.—In morphology, when an organ is not completely suppressed by *abortion*, but only imperfectly developed or peculiarly modified, it is said to have come so by degeneration; as in the case of stamens changing to leaves, or to glands.

DEHISCENT.—Some fruits or pericarps, when mature, open of their own accord, and discharge the seeds; and such are said to be dehiscent. [See PERICARP.]

DESCENT OF THE RADICLE.—When a seed has been deposited in the soil under the proper conditions, the first infallible symptom of its germination is that of the prolongation of the radicle beyond the circumference of the seminal integuments—a prolongation that is uniformly made in the line of descent; either primarily, if it is already so deposited as to point downwards; or ultimately, and through the medium of a bend, if it is deposited otherwise. The opinions of physiologists with regard to the cause of this phenomenon will be given at the article GERMINATION, or, DIRECTION OF THE RADICLE AND PLUMELET.

DEPREDATIONS OF ANIMALS.—As vegetables constitute the principal food of almost all terrestrial animals, they are consequently subject to incessant attack. The animal stimulated by the impulse of hunger must eat; and the plant, unable to resist or to evade the onset of the enemy, must be content to be eaten. But all animals do not devour all plants, nor all parts of a plant indiscriminately. They are very nice and scrupulous in their selection, some giving the preference to one plant, or to one organ of a plant, and some to another.

Many prefer the root. The maggot of *Hepialus Humuli*, the Ghost Moth, attacks and devours the roots of Hops; and the maggot of *Musca radicum*, the root or caudex of radishes. The grub of *Melolontha vulgaris*, the common Cockchafer, which remains in its *larva* state during the space of four years, undermines our meadows and pastures, and devours the roots of grasses. The wire-worm, the grub of the beetle—the *Elater lineatus* of Linnæus, now *Elater Segetis*—feeds indiscriminately on the roots of wheat, rye, oats, grass, turnips, and commits amongst them the most deadly ravages. It is said to live five years in the grub state. [Kirby and Spence, i. 179.]

Many prefer the stem, or general herbage. This is of course the

case with all animals termed herbivorous, or graminivorous, as the Horse, the Sheep, the Ox. Yet the injury done to the plant is but partial and temporary, for the shoots or branches, like the heads of the Lernæan Hydra, are no sooner browsed or bitten off than an increased number of new ones begin to sprout up in their place, and to replenish the fields with food.

Many prefer the leaves, as the *Aphis Humuli*, which attacks the leaf of the Hop-plant, and in some seasons almost totally destroys the crop. Where does this little fly lay its egg so as to preserve it in the winter, and how does it get to the Hop in the spring? This is what I cannot find in any of the books of Entomology, not even in that of Kirby and Spence. The imago of beetles and cockchafers, with the caterpillars of various species of Lepidoptera, attack our forest trees and strip them of their foliage. In the month of June, 1830, many woods of oaks in the Weald of Kent exhibited nothing but a scene of desolation, with not a leaf to be seen throughout their whole extent; but in the place of leaves, millions of caterpillars hanging from the bare branches by a single thread, and dangling in the air. Thus vegetation received a check, but new leaves were soon protruded. Some species prefer the seed-leaves, particularly if very soft and tender, as those of turnips, which are no sooner unfolded than they are attacked by multitudes of little jumping beetles, called by farmers the fly, or black jack, and by Entomologists *Haltica nemorum*, which will destroy a whole field in a night or two; and if you plough and sow it again, a new brood will destroy it a second time. Many expedients have been tried to kill this voracious little insect, or to prevent its attack, but without much success. Whence does it come, and where does it winter? Entomologists do not tell us.

Many prefer the fruit or grain, as monkeys, squirrels, mice, sparrows, thrushes, and are particularly partial to the nicest and most esteemed among men, as nuts, peaches, oranges, grains, berries; and though this may seem to interfere with the wants and claims of man, yet we find that there is always enough for the support and maintenance of every thing that lives; and that the very plunder of which we accuse the animal is often the means of giving a wider dissemination to some particular species of vegetable than was otherwise practicable, by the accidental dropping of the seeds in remote soils favourable to their germination. If birds devour grain, it is to be recollected that they devour also millions of little insects that might be incalculably more destructive to our corn fields. Let us not, therefore, grudge to the rook or to the sparrow their little pittance. They are our friends, not our enemies; and we, as well as they, are but parts of a whole, in which every thing is subordinate to one

grand and ultimate end, present to the mind of the almighty Creator; but

“To us invisible, or dimly seen —
In these [his] lower works.”

PARAD. LOST, B. v. 157.

Many injure the plant, not merely by feeding on it, but by nestling in it, or by depositing their eggs in the tender bud, or shoot. Thus the figure of eight-moth *Bombyx ceruleocephala* nestles in, and destroys the blossom of the apple-tree; and thus the Cherry-fly, *Tephritis Cerasi*, destroys the fruit of the cherry-tree, by laying its egg in the soft and tender ovary. The *Tinea corticella* insinuates itself between the bark and wood and nestles there, injuring the health of the tree, and perhaps laying the foundation of canker. The *Aphis lanigera* or American blight enters the chinks and crevices of the bark, increases, multiplies, and drains the tree of its sap, and finally destroys it. The application of the spirit of tar to the bark is said to be a remedy.

Some grubs devour even dry and sapless timber, and others devour books; but many will penetrate even into the solid substance of the trunk of a vegetating tree. The caterpillar of *Bombyx cossus* devours the wood of the Willow-tree, and the grub of *Bostrichus typographus* bores into the wood of the fir-tree.

I have known a pear-tree to be thus attaked when the stem was about three inches in diameter. The grub had eaten its way to the very centre, as was to be inferred from the bore's beginning at the circumference, and had ascended in the line of the pith to the height of several inches. A sound introduced at the entrance of its burrow, and pushed upwards with considerable force, did not seem to annoy it much; and it was ultimately destroyed only by drilling a hole to the centre, at about the level of its head, and introducing an instrument of iron to demolish its cutting apparatus. I believe it to have been the grub of *Cerambyx gigas*, which, when left to itself, is said to eat its way out again, till it reaches the bark, where, after undergoing its final transformation, it ultimately escapes into the open air, a large winged insect!

Lastly, some insects deposit with their egg a drop of an acrid fluid that causes a vegetable tumour. The insect producing the Gall-nut on the leaf of *Quercus infectoria* is of this description. It is a species of Cynips; and Kirby thinks it ought to be called *Cynips Scriptorum*. [Kirby and Spence, i. 444.] But all galls, whether resembling berries or apples, whether smooth or shaggy, whether on the oak or willow, or on any other plant, are thought to be caused by one or other of the species of Cynips. An egg is deposited in the leaf or bud. A tumour is the immediate result, and, in a day or two, a gall is formed affording both food and shelter for the future larva.

Thus the mystery is unravelled that puzzled Redi, who thought that the grubs of galls were formed by the vegetative power or soul of the plant ; not being aware of the deposition of the egg of the parent fly, and not admitting the doctrine of equivocal generation.

DETACHED CALYX.—When the calyx includes the ovary without adhering to it, it is said, in the language of botanists, to be detached. Hence the detached calyx is the same with the inferior calyx.

DESCENDING ROOT.—The simplists of earlier times were content to account for the phenomenon of the præmorse root by saying that it was bitten off by the fraud or malice of the devil. Modern phytologists have discovered the true cause. A portion of the lower extremity of the root dies, annually, in the soil, while the remainder, augmenting and protruding new fibres at the collar, sinks down, or descends, to supply its place. Hence it is sometimes called the descending root.

DEVELOPEMENT OF THE VEGETABLE OVULUM.—Seeds in their mature state are divisible into two parts, distinguishable without much difficulty—namely, the integuments and nucleus, or embryo and its envelopes. The integuments are generally two, but sometimes three or more, designated by the names of primine, secundine, tercine, quartine. The nucleus consists of the albumen, the vitellus, and the embryo—divisible into cotyledon or cotyledons, and plantlet, which is itself divisible into radicle and plumelet. How have these organs come into existence ; and how have they acquired their present dimensions ? In their origin, as being first sensible to sight, they were a mere speck, a mere globule or *ovulum*, exhibiting no vestiges of specific organization. Now they have acquired bulk, consistency, and distinct visibility. Let us trace their formation and synthesis as closely as we can.

If we suppose the *cambium* or elaborated juice of the plant to be already endowed with vitality, it will tend to facilitate the inquiry, and to render the process more intelligible. Physiologists have been of different opinions on this subject. Blumenbach confined the vitality of animals to the solids ; but John Hunter extended it even to the fluids, particularly to the blood. Perhaps we should extend it to the nutritive or elaborated fluid of vegetables also. At the least we must grant it to the generative fluid. But why should we doubt the possibility of endowing a fluid with vitality ; or in what respect is it more difficult to conceive a fluid endowed with it than a solid ? Solids are themselves engendered out of fluids, and may be again reduced to fluids without the escape of their vitality. Thus the nutriment which is laid up in the cotyledons is, in the mature state of the seed, solid ; but it must be again reduced to the fluid state before it can be made available to the nutrition and developement of the embryo. The rudiments of the solids then, exist already in the fluids ; so that the

former can be nothing more than a closer aggregation of the minute and semi-organized globules of the latter, effected by the agency of the vital affinities of the plant in some specific and determinate manner. How did the fluid acquire the living energy? We might ask the same thing of the solid. All we can safely affirm is, that life does not seem ever to originate in any fluid or fabric *de novo*, but to enter it by communication from some body or substance already endowed with it. In this way we regard it as being communicated from parent to progeny, in the process of generation, giving individuality to the incipient germ, and as being communicated from the aliment already elaborated in the process of nutrition to the ascending sap or juice; giving it the vitality that is proper to nutritive fluids; as leaven communicates its leavening property to substances capable of receiving it.

Thus the germ of a new individual is generated in the vegetable ovary through the aid of means which we cannot trace or detect in their initial agencies, but only in their ulterior results, when the effect has become cognizable to the sense of vision, and at that stage of its developement in which the *ovulum* appears to be merely a soft and pulpy globule, or a gelatinous and homogeneous mass, endowed with the vitality of the vegetable substance, and attached, either immediately to the placenta by a point called its base, or mediately, and by means of a *funiculus*, which is a prolongation of the placenta. Let the student look out for *ovula* in this nascent stage, and let him watch and mark well every succeeding change. No progress can be made without the actual inspection of specimens: To look at figures, merely, is not enough. But if an *ovulum* is taken and examined, at a stage a little more advanced than that which we have now specified, it will be found to be already invested with two proper integuments:—First, an outer integument—the *secundina exterior* of Malpighi—the *testa* of Gærtner—the *primine* of Mirbel; being, in its commencement, a fine and thin film, originating in the outer vessels of the *funiculus*, and traversed with numerous veins.—Secondly, an inner integument, which Gærtner did not designate by a proper name, but which Mirbel denominates the *secondine*; originating in the interior vessels of the *funiculus*, and similar in its structure to the *primine*.

Such are the proper integuments of the incipient *ovulum* or rudiment of the future seed, not yet inclosing a space, but perforated at the apex by a small aperture—the *foramen* of Grew, or the *micropyle* of Mirbel; which he further divides into *exostome* and *endostome*, as relative to the outer and inner integuments respectively. Lay open the *ovulum* by section, and you will find that the proper integuments contain merely a nucleus or globular mass of pulp, furnished with its own proper cuticle—the *tercine* of Mirbel, who represents this

nucleus as being furnished occasionally with an additional and interior cuticle also, to be called the *quartine*. This *nucleus* is the chorion of Malpighi, between which and the outer integuments there is always an organic connexion, though not always at the same point. On this peculiarity M. Mirbel institutes the following distinctions.

If the connexion takes place at the base of the *ovulum*, so as that the base of the primine and the base of the secundine coincide, like one cup within another, with the axis rectilinear, the *ovulum* is said to be orthotropous, as in the *Polygoneæ*. Yet though the point of connexion may remain the same as before, if the ovulum, in its growth, bends down upon itself, so as to bring the apex to a level with the base, and to destroy the rectilinear direction of the axis, the *ovulum* is then said to be campulitropous—rather a clumsy term—as in the *Leguminosæ*. But if the apex of the *ovulum* is pushed round till, in the process of its evolution, it meets the base; and if the base of the *nucleus* is pushed round, also, till it reaches the new apex of the ovulum, not by the bending of the axis, but by a mode of evolution peculiar to the species, then the nucleus is said to be anatropous, though the axis may be still rectilinear, as in the Apple and Almond. In this case, the connexion between the two bases is kept up by means of a *raphe* or internal *funiculus*, whose direction indicates the face of the ovulum, and whose junction with the *nucleus* forms the *chalaza*.

The above appearances are very generally to be met with before fecundation. After fecundation, one of the first visible results is that of the generation of a clear and transparent fluid under the form of a small drop, or globule, occupying the centre of the chorion or nucleus, and invested with a filmy and peculiar cuticle, which, according to Gærtner, originates in the vessels of the internal *funiculus*, and constitutes the *quintine* of Mirbel,—that is, the *sacculus colliquamenti* of the earlier writers, and the *embryonic sac* of botanists of the present day. The contained fluid is the *amnios* of Malpighi; and in the sequel of its developement we find, that as the *amnios* increases the chorion shrinks and diminishes, and is in the end totally obliterated.

Last of all, the embryo, the principal object of fecundation, and end of all the genital apparatus, begins to assume a palpable form, occupying that region of the *nucleus* where the *sacculus colliquamenti* originates, not where the funiculus enters the *testa*. Its first formation eludes the search of the keenest eye aided by the best glasses. But, by and by, as it augments in size and solidity, it becomes at length visible, in some plants sooner, and in others later, after impregnation. In *Helianthus* it is perceptible after the third day; but in *Colchicum*, not till after several months. Its figure is at first globular, its contexture pulpy, and its colour white. It swims in the

liquor amnii, from which it derives its nourishment, seemingly unconnected with any of the integuments; but immersing itself deeper and deeper every day, and always in such a position as to turn the radicle towards the *micropyle*, and its other extremity to the other extremity of the ovulum. Hence, the direction of the embryo depends upon the position of the micropyle; and hence, assuming that the radicle is the base of the embryo, we have the following distinctions. If the micropyle, by an inversion of the integuments, is found to occupy a position next to the *Hilum*, then the base of the embryo and the base of the ovulum coincide, and the embryo is said to be orthotropous, as in the lemon and apple; but if the micropyle is found to occupy a position opposite to the *hilum*, then the base of the embryo and the base of the ovulum are contraries, and the embryo is said to be antitropal, as in *Cistus*. In exogenous plants the apex of the embryo separates into two lobes called cotyledons, embracing and nourishing the nascent plantlet. At length the chorion is exhausted, and the *amnios* absorbed or converted into an *albumen*, and the embryo with its integuments transformed into a perfect seed.

Was the embryo at its first appearance furnished with all the parts proper or peculiar to it; or, are they generated in succession, and in some regular and determinate order? It is certain that the parts of the embryo make their appearance in succession—first the cotyledons, then the radicle, and then the plumelet; though it does not follow that they are generated in succession. But it is impossible for the phytologist, in the present state of his science, to do more than merely to mark the parts as they appear. He cannot lay open the mysteries of generation, he can form only conjectures, and he has formed them accordingly. But we do not enter into the detail of these conjectures at present. We do not now reply to the query concerning the origin of the embryo, as involving the process of fecundation. We take it merely as we find it, in the first stage of its visibility—a small and minute globule, or vesicle, the product of fecundation, discernible in the centre of the fluid drop, and endowed with a distinct and individual life. What it is that determines the fitness of one molecule, or one set of associated molecules, to expand into a cotyledon, another into a radicle, and a third into a plumelet, remains, as it would appear, a mystery which the phytologist cannot yet unriddle. But that being determined, we can readily imagine how the organ progresses in growth by the imbibition of nutriment, which it is enabled to assimilate through means of the vital, and affinial, or chemical agency of its component molecules exerted upon the molecules of the alimentary fluid.

Upon the developement of organized fabrics, M. Raspail theorizes

as follows :—A molecule of carbon and a molecule of water unite, and form by their union a spherical and organic globule. This organic globule or hydrocarbonated molecule combines with a base, earthy, or alkaline, as the case may be, and crytallizes into a cell or vesicle consisting of minute globules or molecules placed side by side, and capable of indefinite extension, by absorbing into its own substance, and there elaborating the liquids or gases with which it is supplied,—assimilating what is necessary to its due developement, and rejecting the rest ; as well as endowed with the capability of producing its type, through the agency, not of chemical affinities merely, but of a specific and vital impulse communicated to it from organs already vitalized. If this impulse is merely vegetative, it generates a vegetative cell ; if sexual, it generates an embryonic cell, the cavity of which becomes a centre of developement to new and secondary cells, which attach themselves by a *hilum* to the interior surface of the primary cell, within which they form nerves, fibres, tubes, by the union of their walls ; while the secondary cells become a centre of developement to additional and tertiary cells, and so on, till the embryo is complete in all its parts.

The above theory of the growth and developement of organized fabrics is advanced under such a firm conviction of its truth and validity, that as Archimedes wanted only a prop to his lever, and a place to stand upon to move the earth, so M. Raspail wants only a vesicle endowed with the capability of producing its type within its own cavity to furnish us with the phenomena of the organized world. “Donnez-moi une vesicule dans le sein de laquelle puissent s’elaborer, et s’infiltrer, à mongré, d’autres vesicules, et je vous rendrai le monde organisé.”—Such is our brief view of the normal formation and synthesis of the organs composing the seed. [Nouv. Syst. de Chim. Org. lxxviii. 547.]

DICOTYLEDONOUS PLANTS.—Plants having two cotyledons are said to be dicotyledonous, and with regard to their mode of augmentation they follow a peculiar law. In the first year of their growth the stem is merely a slender and conical shoot. In the second year it increases in height by an additional and conical shoot, and in width by an additional and circular layer interposed between the bark and wood of the former year ; like the paper that covers a sugar-loaf ; and so in every succeeding year of its growth. Thus its increments of width after the first year are always external ; and plants whose mode of augmentation follows this law are said also to be *Exogenous*. The outermost and last formed layer being always the softest and whitest, has obtained the name of the alburnum, which it retains for one year, and then gives place to a new alburnum. The oak, the elm, and

the ash furnish good examples. Yet this illustration, though applicable to the stem of after years, does not apply well, whether to the growth of the seedling itself, or to that of the annual shoot.

DIÆCIOUS PLANTS.—Plants having their male or stameniferous flowers on one individual, and their female or pistiliferous flowers on another, and separate individuals are said to be diæcious—that is, to have their flowers in two houses. They are exemplified in Hemp, Spinach, Hops.

DIGESTION.—The process through which the nutritive fluids, when absorbed by the root, are elaborated in the interior of the plant, so as to render them fit for final assimilation, constitutes what some botanists call the digestion of vegetables, in contradistinction to the alternate inhalation and extrication of oxygen, and carbonic acid gas, in the night and in the day, as effected by the leaves. This last process is called their **RESPIRATION**—which see.

DIPLOË.—The interior parenchyma that lies between the upper and under layers of the net-work of the leaves, is by some botanists called the *diploë*—a term borrowed from the anatomical nomenclature of the zoologist, signifying the cellular substance that is lodged between the tables of the flat bones.

DIRECTION OF THE RADICLE AND PLUMELET.—If a seed or nut of any kind is placed in the proper soil, with the apex of the radicle pointing downwards, the radicle as it elongates will descend in a perpendicular direction, and fix itself in the earth; and the plumelet issuing from the opposite extremity of the seed will assume a vertical direction and ascend into the air. This is the natural order of the developement of the seminal germ, and from the relative situation of its respective parts, the mode of its developement does not seem to be at all surprising. But the circumstance exciting our surprise is, that the radicle and plumelet will still continue to effect their developement in the same manner,—the former descending into the soil, the latter ascending into the air, whatever may have been the position in which the seed was originally planted; and no human art has ever been able to make them assume contrary directions, or to convert the one into the other, as the root and branches of the vegetating plant may, sometimes, be afterwards converted. Duhamel, whom no phytologist has surpassed in the invention of expedients to unmask or to control the energies of vegetable life, instituted a variety of experiments with a view to effect this conversion, but failed in them all. He first placed an acorn between two wet sponges suspended from the ceiling of his study, so as that the radicle was uppermost, and the plumelet undermost. But the result was that the radicle, after bursting its integuments, assumed a downward direction, and the plumelet,

in its turn, an upward direction, till each had gained its natural position. He then filled a tube with earth, and planted an acorn in it, in an inverted position. Yet the radicle and plumelet had no sooner escaped from their envelopes, than they began to assume their natural direction as before. He then filled another tube with earth, of a diameter so small, that an acorn, when placed in it, touched the sides of the tube. It was planted in its natural position, and allowed to remain so till the radicle appeared. The tube was then inverted, and the radicle began immediately to bend itself downwards. The tube was again inverted, and the radicle resumed its original direction. [Phys. des. Arb. liv. ii. chap. 6.]

Such is the invincible tendency of the radicle to fix itself in the soil, and of the plumelet to escape into the air. How is this tendency to be accounted for? A great many conjectures have been offered in reply, without having done much to elucidate the subject. Some have attributed the phenomenon to the excess of the specific gravity of the juices of the radicle beyond that of the juices of the plumelet, which in their progress upwards were supposed to be reduced by elaboration to a light vapour. But the supposition is contradicted by fact. Others have attributed it to the respective action of the sun and earth; the former attracting the leaves and stem, and the latter attracting the root. Yet this conjecture comes no nearer to the truth than the former. Duhamel made the experiment in a dark room, and had the same result as in the light. Darwin after Doddart endeavoured to account for the phenomenon by transferring the influence of the sun to that of the air, and the influence of the earth to that of the moisture contained in it. The radicle was supposed to be stimulated by moisture, and the plumelet with the cotyledons by air, and hence each was elongated in the direction of its exciting cause. [Phytologia, sect. ix.] This hypothesis is very ingenious, but not very satisfactory. For at this rate all cotyledons ought to rise above ground, which all cotyledons do not, and all seeds ought to germinate either in the earth or water, though many of them will germinate in neither; but on trunks or stumps of trees, or even on the bare and flinty rock. Also the radicle ought to grow upwards if it could be but lodged in the lower surface of an insulated mass of mould, so as to have the moisture of the mass and grand exciting cause of its elongation placed above it. This experiment has, in fact, been made [Lin. Trans. vol. XI. part ii. 255], and yet the growth and elongation of the radicle has been uniformly that of descent.

In this state of mystery the subject was still involved, when Mr. Knight about the year 1806 attempted to account for the phenomenon upon the old but revived principle of gravitation, strengthened by the

result of some experiments that were suggested, perhaps, by the experiment of Mr. John Hunter, in which germinating seeds were made to revolve upon their own axis, by being put into the centre of a horizontal and revolving barrel filled with earth. The result was that the radicle elongated in the direction of the axis; but it led to no specific conclusion. Mr. Knight's experiments were more decisive. Exper. I. On the circumference of a vertical wheel performing 150 revolutions in a minute, by which the influence of gravitation was conceived to be wholly suspended, beans were placed and made to germinate. The radicles were protruded outwards from the circumference, in the line of radii. The germens, that is the plumelets, were protruded inwards to the centre, which passing they approached again. Exper. II. On the circumference of a horizontal wheel performing 250 revolutions in a minute, beans were fastened as before. The radicles were protruded outwards and downwards, about 10° below, and the plumelets inwards and upwards, about 10° above the plane of the wheel. As the rapidity of the wheel's motion was diminished, the direction of the parts was more perpendicular; 80 revolutions in the minute giving an elevation and depression to the root and stem respectively of 45° . Hence Mr. Knight infers "that the radicles of germinating seeds are made to descend, and their germens to ascend, by some external cause, and not by any power inherent in vegetable life; and that there is but little reason to doubt that gravitation is the principal, if not the only agent employed in this case by nature." [Phil. Trans. 1806.]

Such is the hypothesis of Mr. Knight, for which he was lucky enough to obtain a very favourable reception whether among botanists or others. For it was adopted and applauded by men of eminence in various departments of science, and to doubt its truth was, at one time, regarded as a sort of culpable, botanical, scepticism. We do not think that it is now regarded with so much reverence as formerly, and some writers have had the temerity even to attack it.

As for ourselves, we should have been content to let it rest in peace, but that a celebrated phytologist, namely, Professor Decandolle of Geneva, has of late years been pleased to revive and to adopt it, and to defend and bolster it up with the powerful sanction of his high authority to a point at which it can never be supported. [Phys. Veg. ii. 820.] Undoubtedly there is a degree of plausibility in the supposition that the radicle grows downwards by virtue of gravitation; because downward direction is so easy, and seems to us so natural.

"Facilis descensus Averno,
Noctes atque dies patet atri janua Ditis."—VIRG. *ÆNEID* vi. 126.

Yet natural as it may seem, the doctrine cannot be received without

some proof, which proof Mr. Knight finds in the result of the above experiments, warranting as he conceives the above conclusion, which seems to be equivalent to the following proposition; namely, that the radicle descends by virtue of gravitation, because it followed the direction of a power counteracting gravitation.

With regard to the first experiment, we do not deny that gravitation, or a force counteracting gravitation, may affect the growth of plants, and influence the direction of the root or stem in a greater or in a less degree; but we contend that the elongation of the radicle in the direction of gravitation is no proof that gravitation is the sole cause of its descent; as the motion of a steamer in the direction of the wind is no proof that the steamer is impelled solely by the wind. We know there are other causes at work, and if the flood or overwhelming current were even to counteract the motion of the steamer, and fairly sweep her out of her course, still it would be no proof that she had not a power and principle of motion within herself.

Besides, though the radicles elongated in the direction of a force counteracting gravitation, yet that force was during one half of each revolution, at least, acting in the line of gravitation or nearly so, that is, in the direction in which radicles naturally grow, so that it might be said that there was no new case put. With regard to the second experiment, we have only to observe, that the cause, be it what it may, producing the downward growth of the radicle and upward growth of the plumelet, was never much disturbed. Let us look at the *rationale* of the contrary directions.

According to Mr. Knight the *rationale* of the downward direction is as follows:—"The radicle of the germinating seed (as many naturalists have observed) is increased in length only by new parts successively added to the apex or point, *and not at all by any general extension of parts already formed*; so that the matter added being fluid, or changing from a fluid to a solid, may be supposed to be sufficiently susceptible to the influence of gravitation, to give an inclination downwards to the point of the radicle." There is no doubt that many naturalists have been of this opinion, but it is to be believed that they took it up hastily and without due examination, as we confess, we also did, till we began to experiment for ourselves, when we found that the radicles of beans, the very subject of Mr. Knight's wheel experiments, increase in length, not merely by new parts added successively to the apex, but by a general extension of parts already formed. [Thomson's *Annals of Phil.*, April 1818.] Let it not be supposed that the wish to find it so was father of the result. Professor Lindley's experiments on this subject had the same issue. [Introduct. to *Nat. Syst.* 228.] Besides, the germinating radicle

is not like an icicle to the apex of which the trickling, but lingering drop, is frozen; nor is the fluid which it contains free to filter through the earth, like the rain-drop that falls from the resplendent bow of Iris. It is enveloped in a fine but firm epidermis that bounds and restrains it, and prevents it from descending by the mere influence of gravity.

But if gravitation is so influential in taking down the radicle, why does it not take down the divisions of the root also? The spongiolæ of the *chevelure* are more succulent at the point than even the radicle; yet their direction is almost always horizontal. Look at the divisions of the root of an Elm-tree. They creep along to the distance of thirty or forty feet from the caudex, and a little below the surface, but never dip down to any great depth. Further, if gravitation is the cause of the descent of the radicle, why do roots occasionally ascend as the surface of the earth ascends, or why does it make an exception in favour of the radicle of the Mistletoe? For this is also a fact, as will be seen below. Yet if these anomalies were accounted for, and if we were then to admit that the descent of the radicle is attributable to the influence of gravitation, how are we by means of the same cause to elevate the plumelet?

“Sed revocare gradum superasque evadere ad auras,
Hoc opus, hic labor est.”—VIRG. *ÆNEID* vi. 128.

It is indeed a grand trial of our faith, to have to believe that the agency of the same mechanical principle should produce results so diametrically opposite; and here it is that the inconsistency of the hypothesis begins to show itself. Let us see, however, how Mr. Knight unriddles the paradox of the upright direction of the plumelet as resulting from gravitation; his illustration is as follows:—The sap accumulating on the under side of a “deflected germen,” causes that side to elongate, and the point to turn up; and the plant, after a series of corrections in bending from side to side, acquires its upright growth. We will not enter into a detailed refutation of this imaginary process; we will state merely two or three facts with which it seems to be altogether incompatible. Upon Mr. Knight’s principles it is evident that the plant acquires its upright position only in consequence of the original deflection of what he calls the germen, and of the continued and alternate deflection and elevation of the summit of the stem from the one side to the other. But if there be any germen that is not originally deflected, or any stem that is not alternately deflected and elevated at the apex in bending from side to side, then the assumed principle of gravitation cannot act.

Now, the germen, that is the plumelet, of the grasses is in no degree

whatever deflected as it exists in the seed, and yet the stem still grows upright, without any deflection at the summit, even where the seed falls so as to have the plumelet vertical. The same thing may be said of the annual shoot of *Asparagus officinalis*, originating at the depth of ten or twelve inches below the surface of the soil; and of the stem of Palms, and many of the Fungi, which burst through their superincumbent covering of earth or turf, and spring up mathematically erect, supporting even a broad and horizontal cap on their heads, and progressing with a force capable of removing mountains till they reach the surface and escape into the open air. Also, if a bean is planted at the depth of six or eight inches in the soil, it will immediately begin to send up a stem, supporting the still unexpanded and deflected plumelet, which does not unfold its parts till it is elevated above the soil. [Thomson's An. of Phil. No. xlvii. 334.] Now what cause has produced the vertical developement of the above stems? Will it be said that it was the agency of gravitation? Upon Mr. Knight's principles this is impossible—for either the plumelet has never been deflected, or, if deflected, never yet unbent; and if the agency of gravitation, as explained by Mr. Knight, causes the deflected germen to turn ultimately upwards, why does it not [Lin. Trans. vol. XI. part ii. 286] cause the deflected radicle that has been accidentally or intentionally inverted to turn ultimately upwards also? It has been proved that they both augment their mass in the same way, whatever may have been said or sung to the contrary. Hence the effect as resulting from the agency of a mechanical and permanently operating cause, ought to be uniformly and invariably the same; and yet, according to Mr. Knight, it is one thing in the root, and a totally different thing in the stem.

Thus Mr. Knight's hypothesis fails to account satisfactorily whether for the downward growth of the radicle, or the upward growth of the stem; the alleged fluidity of the radicle, and its consequent elongation solely by the point, being assumptions unwarranted by facts; and the alternate deflection and elevation of the summit of the stem, as represented by Mr. Knight, being assumptions unwarranted by observation. The truth is that the cause giving direction to the root and stem of plants, instead of being attributable to the mechanical principle of gravitation, is a cause that is capable of counteracting gravitation, or of overcoming obstacles that gravitation shrinks from. The ascent of the sap in the ordinary process of vegetation is a proof of the first part of this assertion; the ascent of the cambium in the inverted and pendent shoot is an additional proof of it; and there are proofs that are stronger still. The stem of the balsam that has been neglected in its customary waterings, declines, and sinks down, till at

last it lies flat upon the soil. Give it, once more, a copious watering, and in less than an hour it is again erect. The agency of gravitation has been counteracted and controlled. The descent of the tap-root of an oak to the depth of ten or twelve feet, through a stiff and clayey soil, is a proof of the second part of the assertion. The agency of gravitation may have been in some degree available, but we cannot regard it as having been the sole cause of descent, because the density and compactness of a stiff and clayey soil is incompatible with the idea. Still it may be said that our argument is hypothetical. But we will take the experiment of M. Pinot, which is not hypothetical. [Decandolle Phys. Veg. ii. 827.] A grain of *Lathyrus odoratus*, fixed by suitable arrangements, was made to germinate over a vessel filled with mercury. The result was that the radicle took its direction downwards, as in ordinary cases, and plunged itself into the mercury, on its way to the soil;—that is, into a body whose specific gravity was much greater than its own. Hence it seems to follow that the radicle grows downwards, as the stem grows upwards, not by virtue of gravitation, but by virtue of a power superior to that of gravitation.

What is this inscrutable, invisible, and mysterious power, which is thus capable of counteracting or surpassing the agency of gravitation in the economy of growing plants? Evidently the agency of life, which in the investigations and elucidations of Mr. Knight seems to have been wholly overlooked.

To say that the radicle grows downwards, and the plumelet upwards, by virtue of gravitation, solely, seems to us to be about as good logic, as to say that the tail of certain quadrupeds grows downwards and the ears upwards, by virtue of gravitation, solely. But to say that they grow downwards and upwards respectively by virtue of the living energies of the plant, always able to achieve the due development of the several organs of the living subject in the way most conducive to its preservation and health, with the exception of a few casual irregularities,—is to assign a cause adequate to every exigency that can occur—a cause that knows nothing indeed of upwards or downwards, of the right side or of the left side, but that exerts itself in any or in every direction, according to the wants of the individual. How else are we to account for the following fact? If a stake cut from a willow-tree is taken and stuck into the ground, the buds or germs protruded at the lower extremity will descend into the soil and become roots; while the buds or germs protruded at the upper extremity will ascend into the air and become branches. Pull it up and plant it again in an inverted position, and the buds that were before protruded into roots will now become branches; while the buds that were before protruded into branches will now become roots.

Thus there is in plants, as there is in animals, a power of accommodating themselves to existing circumstances, and a sort of organic susceptibility to the wants of the individual, or its parts, causing and regulating their movements, and the growth of their several organs. The radicle requires the support and fostering influence of the soil to give it its due developement, and into the soil the radicle descends. But if there be any radicle to which the support and fostering influence of the soil is not naturally wanted, then that radicle selects, and clings to such a peculiar subject of support as furnishes the conditions required, such as the radicle of the Mistletoe. Hence we maintain that nothing short of the agency of life is sufficient to account for the phenomena in question;—life capable of controlling, or of commanding, and converting to its own purposes, the most powerful agencies in nature, whether chemical or mechanical—as the endosmose and exosmose of Dutrochet, or agency of molecular infiltration, a power known to be capable of resisting the pressure of at least forty atmospheres.

Still it may be true that the descent of the radicle is owing to the agency of some peculiar and specific *stimulus* which remains to be yet detected, and which Dutrochet regarded as being attributable to gravitation; and hence he has been looked upon by some as the disciple and coadjutor of Mr. Knight, and as such Mr. Knight partly claims him. But any one who reads Dutrochet with attention will soon see that the theory which he advances, if well founded, totally overthrows the theory of Mr. Knight, though both of them rest upon the principle of gravitation. According to Mr. Knight gravitation acts upon the radicle and plumelet as it acts upon any other ponderable masses, whether solid or fluid, and yet it draws down the one and elevates the other. According to Dutrochet it acts upon the radicle, merely in the way of a *stimulus*, exciting it to downward growth; and upon the plumelet merely by virtue of an induced polarity or reaction. He admits, however, that the radicle of the Mistletoe is refractory, and cannot be made to yield to the attraction of the earth; though it is at the same time so “gentle and easy to be entreated,” as to yield to the solicitation of any other attracting body that may happen to be near it, as the trunk or branch of a tree. Yet it is from this radicle that he draws his proof of the efficiency of the stimulus of gravitation. He took a grain or berry of Mistletoe in which germination had but just commenced, and glued it to the point of a brass needle like that of the mariner’s compass, finely balanced, and turning upon a very sensible pivot. He then brought near to the seed a piece of board “*placée à un millimetre de distance de la radicule.*” The radicle had not yet shown any inclination to fix itself, but at the end of five days it began to bend towards the board,

though the needle had not moved, and in two days more was in contact with it. This, as he imagines, proves his case. For he infers from the experiment, that the direction of the radicle was not the immediate result of the attraction of the board; but the result of a vital or spontaneous movement to which the board excited it, and by which it grew, but was not drawn towards the exciting cause. He adds that it is indubitably the same with terrestrial plants. [Motilité des Veg. 107.] After all, though this may be a good argument enough against the hypothesis of Mr. Knight, yet it does not establish the hypothesis of M. Dutrochet. For why should not the radicle, excited by the *stimulus* of the earth's attraction, grow downwards into the earth, if placed very near it, as well as it grows towards the tree, by the *stimulus* of the bough or branch? It is as if there was a certain ponderable mass which the application of a ten-horse power was utterly incapable of moving from its place, but which the application of a one-horse power could move in any direction.

Mr. Knight parried the argument drawn from the germination of the Mistletoe, by saying that it has no root, though botanists in general are kind enough to give it one, or by saying that the radicle gains the bough by flying from the light. But Dutrochet has shown that if made to germinate in a dark room, by being suspended so as to be beyond the attraction of any particular body, it assumes all manner of directions, often upwards, but not very often downwards. [Motilité des Veg. 117.] Still if it were even proved that gravitation is the cause of the radicle's descent, whether upon Mr. Knight's hypothesis or M. Dutrochet's, there are other cases of invariably determinate growth that will puzzle the phytologist, and put him as much to his shifts to explain, as growth downwards. How is he to account for the horizontal growth of the creeping stem, or for the spiral growth of the twining stem, or for the circulating growth of the tendril? Gravitation will avail him nothing, neither will polarity; and he must look out, as we suppose, for some exterior and proximate cause that creeps, that twines, that circulates.

Yet this difficulty has not deterred certain other phytologists from embracing the doctrine of gravitation. M. Poiteau is a zealous advocate for it, though upon a principle totally different from that of Mr. Knight; and on this account Mr. Knight scouts his aid, and denounces his essay on the subject in a very summary way by calling it a tissue of blunders from beginning to end. [Journ. of Roy. Instit. 1831.] Still the hypothesis of Mr. Knight, according to Mr. Knight's own interpretation of it, is not without, at least, one advocate of consideration, as we have already shown; namely, the celebrated M. Aug. Pyr. Decandolle of Geneva—himself, it may be said, a host;

though we do not think that he has subjected the hypothesis in question to any very rigid scrutiny; since he accepts as orthodox Mr. Knight's explanation of what may be called the *vegetable paradox*, that is, the regarding of the downward direction of the radicle, and upward direction of the plumelet, as being the result of the operation of the same mechanical cause, and that cause gravitation. In this the learned professor embraces two errors:—1. The elongation of roots by the apex only, as owing to their semifluidity at the extreme points, —“*les racines ne s'allongent que par leur extrémité,*”—and, 2. The elevation of the stem or plumelet, as owing to a previous deflection at the point;—“*ainsi la branche doit toujours se redresser vers le haut*” [Phys. Veg. ii. 822], and thus puts the best face possible upon the weak points of Mr. Knight's hypothesis. But he gives no quarter to the imperfections of any hypothesis opposed to Mr. Knight's. Thus he dismisses M. Dutrochet, by saying that he was so much preoccupied by his ideas of polarity, that he could attend to nothing else; and that as he does not attack Mr. Knight's theory it would be quite superfluous to defend it. M. Dutrochet does not indeed attack Mr. Knight's theory expressly; but he demolishes it as effectually, by means of a side blow, as if he had battered it in breach. His position is, that gravitation acts merely on what he calls the *nervimotilité* of vegetables,—that is, their vital and organic susceptibility, and not at all upon their ponderable mass, alleging that if it acted upon the ponderable mass there would be no such thing as getting up the stem. “*C'est ici qu'ont échoué ceux qui ont tenté à expliquer ce phénomène.*” [Mot. des Veg. 92.]

M. Decandolle regards the experiment of Pinot as the strongest argument that can be brought against the theory of Mr. Knight—“*l'objection la plus grave qu'on pourrait opposer à la théorie de M. Knight;*” and so far we think he is quite in the right. But still, he will not admit that it shakes the stability of Mr. Knight's theory in the slightest degree. On the contrary, and through means of some rule for arriving at a conclusion, known only to himself, he discovers that it rather confirms it. First, he avails himself of the result of an experiment of M. Dutrochet, from which it was inferred that the radicle plunges into the mercury merely to such a depth as its mass of matter requires, in the manner of any other floating body. But as the floating experiment of M. Dutrochet is no fair counterpoise to the fixed experiment of M. Pinot, it is not much insisted on. Secondly, he denies the legitimacy of the conclusion of M. Mulder, and substitutes a conclusion of his own. M. Mulder, who repeated the experiment of M. Pinot, found that radicles of a firm texture, as those of peas and beans, plunge into the mercury, and elongate by descent;

while radicles of a soft texture, as those of buck-wheat, merely creep on the surface and elongate by lateral extension. Whence he inferred that their elongation in either case was owing, not to gravitation, but to some inherent and interior force. M. Decandolle, on the contrary, does not admit the existence of any internal force, but regards the descent of the radicles of the peas and beans as owing merely to their rigidity, and the non-descent of those of buck-wheat as owing merely to their want of rigidity,—a result which he represents as being perfectly conformable to the theory of Mr. Knight.

Thus you have no way of escape from the toils of the gravitationists. Mr. Knight makes the radicle to descend through means of its fluidity at the point; M. Decandolle, through means of its rigidity at the point. Hence no case can come amiss. If fluidity will not do, rigidity is close at hand to supply its place. This is the dilemma which is presented to you. You may choose which of the horns you please, but on one or other of them you must be content to be tossed. We regard M. Pinot's experiment, however, as affording a palpable demonstration of the fact, that the direction of the radicle and plumelet, in the process of germination, is the consequence, not of the agency of gravitation, but of the spontaneous and duly excited energies of the living plantlet, uninfluenced, or influenced in a very slight degree, by the operation of any cause that is merely mechanical. To what extent this opinion has made its way among phytologists we cannot at present positively say, but we think we may regard Professor Lindley as having adopted it; who, after speaking of the theories of Dodart and Bonnet, adds,—that “in consequence of the unsatisfactory nature of these and other theories, more modern phytologists have been satisfied with inscribing the directions taken by plants among the vital phenomena of vegetation, and this is perhaps as much as we are likely to ascertain relating to it, and all similar manifestations of the overruling power of nature.” [Intro. to Bot. 278.] His leaning is apparently to the theory of M. Dutrochet, which he details at some length, and which we have shown to be subversive of that of Mr. Knight, whose theory the professor does not condescend even so much as to mention. This we regret exceedingly, as any notice which he might have taken of it would, doubtless, have thrown light on the subject, and opened the eyes of others less able to judge for themselves. But as he has thus fairly given it the go-by, he has disappointed, as we think, many of his readers, and has, with regard to the theory in question, left them to be guided by the feebler lights of the *minora sidera* of the botanical empyrean.

Yet, in order to throw all the light we possibly can upon this subtle

and mysterious subject, we will adduce, in support of the argument drawn from the experiment of M. Pinot, the facts that follow:—

On the 13th of Nov. 1834, I filled a deal box with earth in which was lodged horizontally a slice of clay of about one inch in thickness, and at about $1\frac{1}{2}$ inch below the surface, over which I placed a few acorns with the radicle downwards, and resting upon the clay. The clay employed was procured from a pit in the neighbourhood of Charing, which is worked for the purpose of making bricks. It was taken from a depth of twenty feet, colour blueish-gray, touch greasy, lustre dull, fracture earthy, surface where cut shining, specific gravity = 2+.

The box was placed in a parlour in which there was a fire every day. The earth was occasionally watered, and the acorns occasionally looked at, up to about the middle of December, without any symptoms of incipient germination; when, despairing of making any progress in my experiment till the return of warm weather, I allowed the box to remain without watering and without examination till the 29th of Jan. 1835, when I again inspected its contents.

The earth that covered the clay was quite dry, and caked, so that I did not anticipate even the commencement of germination. But on removing the superficial layer of earth, I found, contrary to my expectations, that two of the acorns had actually germinated, and pushed their quickened radicles into the firm and compact clay, which was also dry;—the radicles being sufficiently strong to support the acorns in the upright position, even when the superficial layer of earth was removed from around them. In doing this one of the radicles was broken off at the collar, and left fixed in the clay. The superficial layer was now replaced, and well watered, and more acorns planted.

At the same time a block of clay three inches thick by twelve in length, and eight to ten in breadth, was let down into the soil of one of the compartments of my garden, and covered with a thin layer of mould, in which were sown or planted, beans, wheat, oats.

In the above state, all was left, in both cases, till the 9th of March, when I took up the cake of clay in the box, and found that the radicle from which the acorn with stem and plumelet had been broken remained as before without progression downwards; but that the radicle of the acorn which was left unscathed had now perforated the clay in a slanting direction, and penetrated into the mould below it to the depth of upwards of more than three inches, being now, upon the whole, five inches in length. Also an acorn that was planted on the 29th of Jan. so as to touch the clay had protruded its radicle in a horizontal direction, and along the surface of the clay, for about the

space of an inch, when it was found to have taken a turn downwards, and penetrated into the stiff clay, by nearly half an inch.

On the same day, the 9th of March, I took up the clay that was deposited in the garden. The wheat and oats had sprouted to the height of about a couple of inches, and the beans to that of about one inch above the soil. The radicles or roots had not merely penetrated into the clay, but had actually passed through it, and plunged into the soil below, exhibiting a length of five or six inches.—Mark this. The limber roots of the Grasses.

Such were the experiments, and such the results ;—and with the above facts before us, are we still to believe “that gravitation was the principal, if not the only agent that was employed in the above cases by nature,” to do what?—to cause the radicle to take a downward direction, and to penetrate and actually pass through a stiff and tenacious body of a greater specific gravity than itself; not merely in the case of roots of a stiff and rigid texture, as in those of the acorns; but even in the case of the slender fibres of the grasses, which you may twist round your finger like a thread; and still further, to cause the plumelet, at the same time, to take a different direction upwards. If we were to say that we believed it, it could be only upon the principle of the famous *Credo quia impossibile est* of a celebrated character of primitive times. But this would be a species of credence for which the author of the theory in question would scarcely regard us as being entitled to his thanks.

From the above experiments, therefore, coupled with that of M. Pinot, we think that any further attempt to account for the direction of the radicle and plumelet respectively, upon mechanical principles solely, must be utterly hopeless; and that the enlightened phytologist will, for the future, see the necessity of calling to his aid principles of a higher order. Life, life with its energies and affinities, is alone capable of accounting for the phenomena!

Since the above was written, we find that Professor Henslow of Cambridge has briefly noticed Mr. Knight's theory of gravitation, in his “Sketch of Descriptive and Physiological Botany,” published in Lardner's “Cabinet Cyclopædia.” He admits that gravitation may certainly have considerable effect in giving the downward direction to the roots of plants, and this is what no one denies; but he does not seem to be able to comprehend, even with the help of Mr. Knight's explanation, how the agency of the same cause should also give the upward direction to the stem. What he says is,—“Perhaps we want sufficient data to allow us to lay any great stress upon this explanation.” [Cab. Cyc. vol. lxxv. 293.] If the professor, after a full and impartial investigation of the subject, had felt that he was authorized

to express himself in language more favourable to Mr. Knight's theory, we have no doubt he would have been ready to do so.

DISEASES OF PLANTS.—Diseases are corrupt affections of the vegetable body, arising from a vitiated state of its juices, and tending to injure the habitual health either of the whole or of a part. The diseases that occur the most frequently among vegetables are the following:—blight, smut, mildew, honey-dew, dropsy, flux of juices, gangrene, consumption, of which a specific account will be found under their respective heads.

DISK.—In the language of the followers of Linnæus the disk denotes the central portion of the receptacle of such compound flowers as have the florets of the ray different in shape from those of the centre. In the language of the followers of Jussieu it denotes certain peculiar substances situated, for the most part, between the base of the ovary and the base of the stamens, and in the form of a fleshy ring, or of fleshy lobes, as in *Lanium*, in which case it is hypogynous; or assuming the form of a cup, and adhering to the calyx, as in *Amygdalus*, in which case it is perigynous; or surmounting the summit of the ovary, as in the *Umbelliferæ* and *Compositæ*, in which case it is said to be epigynous. [Lind. Introd. 137.]

DISPERSION OF SEEDS OR SPORULES.—When the seed has reached maturity, in the due and regular course of the developement of its several parts, it detaches itself sooner or later from the parent plant, either singly or along with its pericarp, and drops into the soil, where it again germinates, and takes root, and springs up into a new individual. Such is the grand means instituted by nature for the replenishing and perpetuating of the vegetable kingdom;—the wisdom and efficacy of which will equally appear, whether we regard the great fertility of vegetables in general; and the incalculable fertility of some species in particular; or, the care with which nature has provided for the dispersion of the ripened seed.

If seeds were to fall into the soil merely by dropping down from the herb or tree, then the great mass of them, instead of germinating and springing up into distinct plants, would tend only to putrefaction and decay:—to prevent which consequence nature has adopted a variety of the most efficacious contrivances, all tending to the dispersion of the seed.

The first I shall mention is that of the elasticity of the pericarp of many fruits, which open when ripe with a sort of sudden spring, ejecting the seed with violence, and throwing it to some considerable distance from the plant.

The seeds of oats when ripe are projected from the glume or calyx in this way; and with such force, that if you happen to pass through

a field of oats ready for the sickle, on a fine and dry day, you may even hear the snapping noise with which the calyx bursts. The scales of the cone, after having hung its twelvemonth on the tree, open also in this way; and if a number of them happen to burst at the same instant, the noise is such as to be heard at some considerable distance.

The toothed or twisted awn of many of the grasses aids also the dispersion of the seeds, owing to its property of contracting by means of drought, and expanding by means of moisture, so as to be affected by the slightest change of weather or of atmosphere. For in these alternations, the teeth or minute hairs, pointing all to the apex, and clinging to whatever object they meet, act as fulcra to carry forward the seed in the direction of its base, till it either germinates or is destroyed.

It is obvious, however, that the modes of dispersion now stated can never carry the seed to any great distance. But where distance of dispersion is required, nature is also furnished with a resource. Many seeds are carried to a distance from their place of growth, merely by their attaching themselves to the bodies of such animals as may accidentally happen to come in contact with the plant, in their search after food; the hooks or hairs with which the pericarp or fruit is often furnished serving as the medium of attachment, till it is again accidentally displaced, and at last committed to the soil. The seeds of *Bidens* and the fruit of the Burdock are often carried about by cattle in this way. The seeds of Drupaceous fruits are very often dispersed by animals also. Cherries, Sloes, Haws, are carried off by birds till they meet with some convenient place for devouring the pulpy pericarp, and then let the stone fall into the soil. Some seeds are even taken into the stomach of the animal, and afterwards deposited in the soil, or in a station favourable to their germination. Thus the seeds of the Mistletoe are first swallowed by the thrush, and then deposited upon the boughs of such trees as it may happen to alight upon. It is even said that the seeds of *Magnolia glauca* refuse to germinate till they have undergone a similar process. In addition to the instrumentality of brute animals in the dispersion of seed I might state also that of man; who, for purposes of utility and of ornament, not only transfers to his native soil seeds indigenous to the most distant regions, but sows and cultivates them with care. But I proceed to other modes instituted by nature.

One of the most effective of remaining modes is that of the instrumentality of winds, the impulse of which many seeds are well calculated to obey;—some from their extreme minuteness, such as the seeds or sporules of the mosses, algæ, and fungi, which evaporate from their cells like steam, and ascend like smoke or dust into the

atmosphere, where they are borne about by winds till they have acquired a greater specific gravity than the medium in which they float, when they again descend, ready to spring up into plants wherever they may happen to alight, or to meet with a suitable soil. Others are fitted for it by means of an attached wing, as in the case of a Fir-tree and Tulip-tree, in which the seed, as it falls from the cone or capsule, is immediately caught by the wind and carried to a distance. Others are fitted for it by being furnished with an aigrette or down, as in the case of the Dandelion and most plants of the class Syngenesia, which with its attached seed you may often see floating on the atmosphere, about the time at which the seed is ripe. Others are fitted for it by means of the structure of their pericarp. Thus the inflated capsule of *Staphyllea trifolia* seems evidently intended to aid the dispersion of the contained seed by exposing a large and extended surface to the wind.

Finally, a further means adopted by nature for the dispersion of the seeds of vegetables is that of the instrumentality of streams, rivers, and currents of the ocean. The mountain stream or torrent washes down to the valley the seeds which may accidentally fall into it, or which it may happen to sweep from its banks when it suddenly overflows them. The broad and majestic river, winding along the extensive plain, and traversing the continents of the world, conveys to the distance of many hundreds of miles the seeds that may have vegetated at its source. Thus the southern shores of the Baltic are visited by seeds which grew in the interior of Germany, and the western shores of the Atlantic by seeds that have been generated in the interior of America. Further fruits indigenous to America and the West Indies have sometimes been found to be swept along by the currents of the ocean to the western shores of Europe, such as the fruit of *Mimosa scandens* and *Anacardium accidentale*, which though they could not be expected to vegetate on the coast on which they were thrown, owing to soil or climate; yet it is to be believed that fruits may have been, often, thus transported to countries or climates favourable to their vegetation.

DISSECTION OF SEEDS.—In the dissection, or anatomy, or analysis of the matured seed, no botanist has been so successful as Gærtner. His work "*De Seminibus et Fructibus Plantarum*" [Stutgardiæ 1788. Tübingæ 1791], a work meritorious beyond all praise, while it furnishes the most finished model of carpological analysis that was ever presented to the world, exhibits also, at the same time, the most durable monument that could have been erected, of the indefatigable industry and profound research of its author; so minute in his investigations that nothing has escaped him, and so faithful in his de-

lineations that no one has ever surpassed him. Hence, though many advances have been made in carpological investigation since the time of Gærtner, and sundry of his errors detected, yet nothing has been done to supersede the necessity of studying his works, which are to be carefully consulted by the young botanist or phytologist, in conjunction with the actual inspection and analysis of seeds. The mass of every seed may be regarded as consisting of two principal parts, distinguishable without much difficulty; namely, the integuments and nucleus, or embryo and its envelopes.

The integuments proper to the ripened seed are two in number—an exterior integument and an interior integument. The exterior integument, which Gærtner denominates the *testa*, is the original cuticle of the seed, not detachable in the early stages of its growth, but detachable at the period of the maturity of the fruit, and of a leathery or crustaceous texture. It may be very easily distinguished on the transverse or longitudinal section of the seed of the apple or of the lemon, and may be also easily detached by the aid of a little manipulation. If detached entire, it will be found to have been a single and individual envelope, without any disruption of continuity, except that occasioned by the hilum or scar, or by the foramen or aperture of Grew, or micropyle of Mirbel. In *Diospyrus* and *Royena* it has the appearance of being composed of two valves, but when inspected more minutely, it is found to consist of one only. Its colour is generally of a deeper shade than the parts which it contains, as in the seed of the privet; yet sometimes it is found to be perfectly pellucid, as in that of *Oryza*. This integument is the primine of M. Mirbel. The interior integument, which Gærtner did not designate by any proper name, is not, like the testa, always easily detected. But it is easily detected in the seed of a ripe Apple or Lemon. It is the secundine of M. Mirbel; and, like the primine, it consists of one entire piece perforated by the micropyle, and separable without much difficulty from the *nucleus*, but not always so from the testa. It has its origin in the interior of the hilum or external scar of the seed, either, immediately, by expanding at once into a multiplicity of ramifications connected together by a fine and delicate membrane that lines the exterior integument, and directly envelopes the *nucleus*, as in *Rhamnus*;—or, mediately, that is through the intervention of an internal *funiculus* or umbilical cord, issuing from the *hilum* or base of the seed and extending in the line of its face till it ultimately reaches the apex, and assumes the form of a scar or tubercle, from whence the expansion commences, as in the seed of the Apple. This tubercle is the chalaza of Gærtner; its area, the base of the *nucleus*; and the cord connecting it with the hilum, the internal raphe of botanists;—the

external raphe being the funiculus by which the seeds of some genera are attached to the placenta or pericarp. In the former case, the base of the seed and the base of the nucleus are identical; in the latter case, they are diametrically opposite.

Progressing inwards, you come next to the *nucleus* or kernel, and find that it, also, is enveloped in its own proper integument, and, in some peculiar cases, in a secondary integument besides. The contents of the *nucleus*, are the *albumen*, with the *vitellus* when present, and embryo.

The Albumen, a term introduced by Grew, is, in the ripened seed, an organ resembling in its consistence the white of an egg when boiled, and forming, in most cases, the exterior portion of the *nucleus*, but always separable from the interior or remaining portion. It was denominated by Malpighi the *secundinæ internæ*, and by Ventenat the *perisperm* [Tab. du Reg. Veg. i. 491], because in many seeds it invests the embryo, as in that of the privet; and because the term albumen is in some measure appropriated to chemistry, with which it is desirable that the terms of botany should not interfere. The latter reason is an argument of some weight against the use of the term albumen; but the former is no very strong argument in favour of the term perisperm, because the organ which it is meant to denote is also very often surrounded by the embryo, or nearly so, and situated in the axis of the seed, as in the Caryophyllaceæ, or it is altogether wanting, as in the Leguminosæ.

The figure of the albumen is generally that of the external integuments; roundish if the seed is roundish, and oval or otherwise, if the seed is so. But to this rule there are many exceptions. The surface is smooth or furrowed, or interrupted with chinks or clefts. When it is not itself central it contains internally a cell or cavity for the embryo, and sometimes two such cavities, of which the one has been said to be always empty [Seneb. Phys. Veg. ii. 198], but this is evidently contradicted by the example of the seed of the Mistletoe, *Viscum album*, the albumen of which contains two cavities and two distinct embryos, as the dissection of the berry will show. In the grasses it is farinaceous, in the Umbelliferæ it is woody, in the seed of the coffee plant it is horny, and in that of the Date-palm it is said to be as hard as a stone. Its colour is generally whitish, but in *Bocconia* it is yellow, in Codon it is red, and in the Mistletoe it is green. Lastly, the albumen of most seeds is altogether without odour and without taste; but in ginger, nutmeg, and pepper it is sapid and aromatic.

The vitellus is an organ of a fleshy but firm contexture, situated, when present, between the albumen and embryo, to the former of

which it is attached only by adhesion, but to the latter by incorporation of substance, so as to be inseparable from it except by force. Hence it seems to have been supposed to bear the same relation to the embryo which the yolk of the egg bears to the cicatrice, as well as to exhibit a character by which it may be always distinguished from the mass of the albumen. It had been observed by Malpighi and others of the earlier phytologists, but not named nor distinctly characterized, till it was studied and described by Gærtner; though even now there are many botanists who do not regard it as constituting a vitellus, but merely as a part of the embryo peculiarly organized. But whatever may be the value of that opinion or the contrary, the organ in question, though not very common, is by no means rare. It pervades the whole of the useful and extensive family of the Grasses, in which it is interposed between the albumen and embryo in the form of a scale. We are aware that it is regarded by Professor Lindley as being the cotyledon of the grasses [Introd. to Bot. 191]; but we confess that we are not yet prepared to receive this doctrine. We are still disposed to cling to the doctrine of Gærtner; or, if that is not tenable, to adopt the opinion of Dr. Brown, who is said to regard the alleged vitellus as being nothing, after all, but a species of albumen, co-existent with the main albumen even in the same subject. [Arnott Encyc. Brit. Art. Bot.]

The embryo, which is the last and most essential part of the seed, and final object of the fructification, as being the germ or primordial rudiment of the future plant, is a small and often very minute body, enclosed within the albumen, and central, as in the umbelliferæ; or enclosed within the albumen, but eccentric, as in asparagus; or accumbent on the external integuments, and hence peripheral, as in the grasses; or occupying the whole of the cavity formed by the proper integuments, as in all exalbuminous plants,—the *leguminosæ* and many others. It is discoverable, for the most part, in the transverse section of the *nucleus*, and is said to be found single in all known seeds, with a few exceptions, particularly that of the Mistletoe, which contains evidently two distinct and entire embryos, embedded in the substance of the albumen, with the summits near the centre, and the radicles diverging to the circumference like the rays of a circle, the albumen being somewhat circular in its contour, and lenticular in its mass, and measuring when ripe about one-fifth of an inch in diameter, and the embryos being somewhat pestle-shaped in their aspect, and measuring about one-tenth of an inch in length. It consists for the most part of two distinct and conspicuous portions; namely, the cotyledon or cotyledons, and plantlet.

The cotyledon, a term introduced by Linnæus as a substitute for

the term seed-lobe, is that portion of the embryo which encloses and protects the tender plantlet, and springs up during the process of germination into what is usually denominated the seminal leaf if the lobe is solitary, or seminal leaves if there are more lobes than one. In the former case the seed is said to be monocotyledonous; in the latter case it is said to be dicotyledonous. Dicotyledonous seeds, which are proper to by far the majority of cotyledonous plants, including a class of at least 32,000 species, are well exemplified in the Garden Bean, in which the cotyledons appear, as in many other seeds, immediately under the proper integuments, in the form of two large, white, and smooth lobes, of a plano-convex figure, and fleshy but firm contexture, without indentations or divisions, having the flattened surfaces closely applied together, and forming conjunctly a sort of kidney-shaped figure, as well as constituting the principal mass of the seed. In other cases the lobes are in their united figure cylindrical, as in *Pisonia*; or spiral, as in the Pomegranate; or sickle-shaped, as in *Canella*; or hooked and semicircular, as in the *Lychnideæ*; or they are cleft, as in the Lime-tree. They are also, for the most part, divisible without much difficulty, as they are not united by the whole of their tangent surfaces; though there are some examples, as in *Tropæolum*, in which the flattened surfaces do finally coalesce, about the time of the maturity of the fruit. Their colour is generally white or green; but in the ripe seed of leguminous plants it is often yellow, and in the seeds of *Bidens* and *Zinnia* it is purple. They are generally without smell, but if they have any it is not mild or aromatic. Their taste is for the most part hot and bitter, but in the almond, nut, and walnut, it is sweet and grateful. Monocotyledonous seeds, which are proper to a class of plants including at least 6000 species, may be exemplified in the palms, grasses, lilies, asphodels. Yet the cotyledon does not present itself as a distinct or peculiar organ till such time as it receives its full developement in the process of germination, unless you regard the vitellus of Gærtner as being the cotyledon of the grasses; for that organ is sufficiently visible, even before the maturity of the seed. But the embryo of monocotyledons in general, as it exists in the seed, seems to be merely a small, solid, cylindrical, and homogeneous body, slightly conical at each extremity, and lodged in an albumen, but without exhibiting any indication of their divisibility into several parts which is so obvious in the embryo of dicotyledons. Let the reader dissect a few seeds of *Asparagus*, and he will find an example of the fact we now state.

As there are some seeds whose cotyledon consists of one lobe only, falling short of the general number, so there are a few whose cotyledon is divisible into several lobes, exceeding the general number.

They have been denominated polycotyledonous seeds, and are exemplified in *Lepidium sativum* or common Garden Cress, of which the lobes are six in number; as in that also of the different species of the genus *Pinus*, in which they vary from three to twelve. There is yet an additional distinction that has been instituted among cotyledons, namely, that by which they are divided in epigeal and hypogeal; the former springing up during the process of germination, and being converted into seminal leaves, as in the case of the Carrot and Radish; the latter undergoing no perceptible evolution, but remaining enclosed within the proper integuments of the seed, and concealed under the surface of the soil, as in the horse-chestnut and walnut. Du Petit Thouars [Cours. de Phyt. Scan. i. 72] says that the cotyledons of dicotyledonous seeds may be either epigeal or hypogeal; but that those of monocotyledonous seeds are always hypogeal. To this last affirmation we are disposed to demur. Is the cotyledon of *Allium Cepa* hypogeal?

The plantlet, which implies merely the future plant in miniature, is the interior and most essential portion of the embryo, and seat of seminal life. In some seeds it is so minute as to be scarcely perceptible, in others it is so large as to be divisible into distinct parts, as in the Garden Bean, in which it is situated near the scar, being partly lodged within the lobes, and partly projecting, in the shape of a small and conical process, beyond the line of their circumference, and uniting them together. The portion that is lodged within the lobes is the plumelet or rudiment of the future leaf and stem; and the portion that is lodged without the lobes is the radicle or rudiment of the future root, or at least the interior of it is so; for in some cases the exterior is merely an envelope through the apex of which the true radicle is protruded. Upon this peculiarity M. Richard founded his division of *Endorizes* and *Exorizes*, which he represented as corresponding to monocotyledonous and dicotyledonous plants respectively. Yet we cannot regard the correspondence as complete; for the radicle of the Horse-chestnut, which is dicotyledonous, is evidently protruded from a sheathing envelope as well as that of the grasses, which are monocotyledonous.

The radicle is the most constant of all the parts of the seed, being often found where the plumelet is not at all perceptible. It is solitary except in some, or perhaps in all of the grasses, and generally conical in its shape, as already described. It is said to be superior if situated near the summit of the seed, as in the Oleaceæ; and inferior if situated near the base of the seed, as in the Compositæ. It is the base of the embryo, and is always found at the foramen or micropyle of the seed; while the cotyledon, which is the summit of the embryo, is always

directed towards the *chalaza* where a chalaza exists. If the hilum and micropyle coincide, the embryo has the same direction as the seed, and is said to be homotropous, as in *Pyrus*; and if it is also straight it is said to be orthotropous; but if the hilum is at the one extremity of the seed and the micropyle at the other, then the embryo is said to be antitropous or inverted, as in the *Hydrocharis*; and if the micropyle is situated at the one side of the seed with the cotyledons directed to the other, then the embryo is said to be heterotropous or horizontal, as in *Myrsine*.

The plumelet, so denominated from its resemblance, in some cases, to a small feather, is the summit of the infant plant. It is not discoverable in monocotyledonous seeds, except as it is said in a few of the grasses, and even in dicotyledonous seeds it is not always easily detected. It is easily detected however in the Garden Bean, between the lobes of which it lies enclosed in the form of two small leaflets pressed close together, and intersected with a large number of fine nerves or veins. It issues for the most part immediately out of the radicle, without the intervention of any thing like an incipient stem; yet there are some embryos, such as those of *Viscum album*, and *Berberis vulgaris*, in which the vestiges even of an incipient stem may be discerned; so that it may truly be said that there is no part of the full-grown plant that does not already exist in miniature in the tender embryo, waiting only the concurrence of favourable circumstances to give it evolution. Such is our brief view of the analysis of the matured seed founded chiefly on the representations of Gærtner.

DISSEPIMENTS.—Dissepiments are the partitions that form and separate the several cells of the compound fruit or ovary, the peculiarities of which will be detailed under the head of **THE STRUCTURE OF PERICARPS.**

DIVERGENT LAYERS.—The divergent layers are layers proper to exogenous plants. They intersect the concentric layers in a transverse direction, proceeding from the centre to the circumference of the stem or branch, and constitute a considerable proportion of the wood, as may be seen on a horizontal section of the Fir or Birch, or of almost any woody plant, under the form of lines diverging like the radii of a circle. But if the wood is split longitudinally, as in a direction passing through the centre of the stem, fragments of the divergent layers will be seen adhering to the surface of the fracture, in the form of large and smooth plates, which cross the concentric layers, and form a sort of binding and cement to the whole, exhibiting a slight resemblance to a fine but irregular wicker-work. This appearance is peculiarly conspicuous in the trunk of the Elm-tree and Oak, if riven in the above direction, and in the latter, even after having been planed,

the irregular fragments of the transverse plates being of a deeper shade of colour than the rest of the wood, as may often be observed even in the flooring or wainscoting of a room, of which the materials are Oak.

The divergent layers were, at one time, and with some botanists are still, denominated the Medullary rays, upon the presumption of their originating in the pith. The thicker and more conspicuous of the divergent layers may, indeed, be traced from the circumference to the centre; but the thinner and intermediate layers cannot always be so traced. Daubenton says that he could not trace any of them quite to the pith; but this is by no means the case in all sorts of wood. If a thin slice of one of them is taken from the split surface of the trunk of an Oak or Elm, and put under a good glass, it will be found to be composed of an assemblage of parallel fibres, or threads of contiguous vesicles, not forming a net-work, but closely crowded together and compressed into a thin layer, being apparently nothing more than the vesicles or cellular tissue of the pulp that originally existed in the alburnum now deprived of its parenchyma, but still filling up the interstices of the concentric layers, and binding them together like the woof of a web. It gives no indication of being composed in any degree of vascular tissue, “unless those curious plates described by Mr. Griffith in the wood of *Phytocrene gigantea*, in which vessels exist, should prove to belong to the Medullary System.” [Lind. Introd. to Bot. 64.]

DOUBLE FLOWERS.—Flowers have often some of their parts accidentally multiplied to the exclusion of others. This anomaly occurs most frequently in the multiplication of the divisions of the corolla by the conversion of part of the stamens into petals; and whenever a flower is thus metamorphosed in any degree, it is generally called a double flower, though the appellation ought to be restricted, as we believe, to the lowest degree of multiplicity—that is, when the petals of the corolla are only so multiplied beyond their normal number as to form not more than a double row.

DOWN.—The down is a species of pubescence, being a fine and plume-like substance that covers the surface of some leaves and surmounts the seeds of some compound flowers. It is sessile or pedicled, simple or branched. Every schoolboy knows it, as it occurs in Goat's beard and Dandelion; and has, no doubt, often had recourse to it, to know the hour of the day. It was at one time regarded as the calyx of the individual florets of the Compositæ, and although its figure is like any thing rather than that of a calyx, yet in the *Helianthus* it may be said to make an approach to it.

DROPSY.—Plants are liable to a disease that seems to arise from

long continued rain, or too abundant watering. Willdenow calls it dropsy, and describes it as occasioning a preternatural swelling of particular parts, and inducing putrefaction. [Princ. of Bot. 249.] It is said to occur chiefly in bulbous and tuberous roots, which are often found much swelled after rain. It affects fruits also, which it renders watery and insipid. It prevents the ripening of seeds, and occasions an immoderate production of roots from the stem. Succulent plants in particular, are apt to suffer from too profuse waterings. The leaves drop even though plump and green, and the fruit drops before reaching maturity. The absorption seems to be too abundant in proportion to the transpiration. A soil too much manured produces similar effects. Duhamel planted some Elms in a soil that was particularly well manured. They pushed with great vigour for some time; but at the end of five or six years they all died suddenly. The bark was found to be detached from the wood, and the cavity filled up with a reddish-coloured water.

DRUPE.—The Drupe is a fruit consisting of a soft and pulpy pericarp that encloses a nut, as the Peach or Cherry. Let us look at it as it occurs in the Nutmeg, as being a rare fruit to find, entire, in this country. On the 6th of June, 1835, I received from Alexander Swan, Esq., of Hythe, in Kent, a preserved nutmeg for dissection. Its figure was pear-shaped, its colour a dusky brown, occasioned, perhaps, by the sirup in which it had been preserved. Its longitudinal axis was $2\frac{1}{8}$ inches, its transverse diameter $1\frac{3}{4}$ inch. The sarcocarp, with its epicarp, when cut open in the line in which it would have opened spontaneously if it had been left to ripen on the stem, was found to be about $\frac{1}{2}$ inch in thickness, at the middle of its length, enclosing the shell or endocarp, which with its aril, the mace, was about $1\frac{1}{2}$ inch in length, by 1 inch across at the greatest breadth. The mace was, as it is usually met with, skinny and membranous, and of a bright orange, imbedded in beautiful streaks on the surface of the endocarp, which it covered entirely except at certain longitudinal openings where its continuity is interrupted. The naked nut measured $1\frac{1}{8}$ inch in length, by $\frac{7}{8}$ in breadth; and when cut open, the shell was found to be firm and hard, and about $\frac{1}{12}$ inch in thickness, enclosing the kernel, soft and full of gaps, and of a pale, dusky-looking orange.

DUCTS.—The *fausses treachées* of Mirbel, the tubes corpusculifères of Dutrochet, the Vaisseaux lymphatics of Decandolle, and the sap vessels of Grew and others, are all classed by Professor Lindley under the denomination of ducts; which are scarcely allowed to be vessels, and yet they are vessels after all. Some are annular, some are reticulated, some are dotted, and some akin to spirals. We do

not see that any particular advantage results from regarding them in this light. A dotted duct is a doubtful spiral; or, it is a genuine spiral according to Kiesser; or, rather, it is a mere succession of cylindrical cells, according to Professor Lindley.

DURAMEN.—The several zones of wood which are successively added to the trunk of exogenous plants, though at first colourless, acquire with age a deeper tinge, and are converted into what is called the duramen or heart-wood of the plant. The colour differs much in different species. In the Oak it is of a deep brown; in Guaiacum it is green, and in Ebony it is black.

E or Ex, in the composition of botanical terms, is merely the *e* or *ex* of the Latins, expressing negation; as *eductulosæ*, without ducts, *exstipulatæ*, without stipules.

EARTHS.—The only earths which have hitherto been found in plants are the following: lime, silica, magnesia, alumina, and perhaps barytes. The chemical process by which they are readily detected is that of incineration. They constitute part of the residuum of the ashes.

Lime occurs in many plants, chiefly under the modification of phosphates, carbonates, or sulphates. Of these the phosphates are the most abundant, but especially in the earlier stages of vegetation. A hundred parts of the ashes of the leaves of the oak gathered in May furnished 24 parts of earthy phosphate—gathered in September, they furnished only 18.25. [Saussure sur la Veg. chap. 9.] At times this salt assumes the form of small needle-shaped crystals. M. Raspail put a small fragment of the leaf of *Phytolacca decandra* upon a drop of water that was placed on the stage of his microscope, and immediately there began to appear multitudes of little needle-like substances in motion, uniting by the one end in a central point, and diverging by the other in the form of stars. When tried by the proper tests they proved to be crystals of phosphate of lime. [Nouv. Syst. de Chim. 520.] Carbonates, next to phosphates, are the most abundant of the earthy salts found in vegetables. They abound chiefly in the bark, as in the cork-tree, as well as in the leaves of *Aconitum Napella*, and in the roots of *Polygala Senega*. Sulphate of lime has been met with in the roots of briony, rhubarb, and opium, and in the bark of the birch and willow. [Decandolle Phys. Veg. i. 382.]

Silica is not found to exist in a great proportion in the ashes of vegetables, unless they have been previously deprived of their salts by washing. The ashes of the leaves of the Hazel-tree gathered in May yielded only 2.5 parts of silica in the 100; but the leaves of the same plant when washed yielded 4 parts in the 100. [Sauss. sur. la Veg.] The greater part of the grasses contain a very consider-

able proportion of silica, as do also plants of the genus *Equisetum*. Sir H. Davy found that in 100 parts of the epidermis of the following plants the proportions of silica were as follows:—Bonnet Cane 90, Bamboo 71.4, Stalks of Corn 66.5, Common Reed 48.1. [Agri. Chem.] Plants that yield silica in such abundance are often used to give a polish to substances requiring smoothness of surface. The Dutch Rush, a plant of this sort, is used to polish even brass.

Magnesia does not exist so abundantly in the vegetable kingdom as the two preceding earths. It has been found, however, in several of the marine plants, particularly in the Fuci. But *Salsola Soda* contains more of magnesia than any other plant yet examined. According to Vauquelin, 100 parts of it contain 17.929 of magnesia.

Alumina has been detected in the ashes of several plants, as in that of the root of Mallows; the leaves of the Olive, and the bulbs of Garlic; but never except in very small quantities.

ELABORATION.—Elaboration is the process by which aliment, after being absorbed or inhaled by the root or by the leaf, is depurated and prepared by the proper organs for final assimilation.

ELABORATION OF SAP.—The moisture of the soil impregnated, as we may believe, with a portion of all such soluble ingredients as the soil may contain, whether of vegetable or animal origin, is no sooner absorbed by the spongiolæ of the root, than it begins to undergo a change,—a change that increases as the sap ascends. This is proved by the experiment of making a bore, or incision, in the trunk of a tree, and at various heights, during the season of bleeding. The sap that issues from the wound possesses properties very different from the mere moisture of the soil; as is indicated in many cases, by the mere taste, or flavour. The sap of the Birch-tree, if extracted near the root, is almost without taste; but if extracted at the height of six or seven feet, it is sweet and palatable, even as it issues from the trunk, and may also be manufactured into a very pleasant wine. Or the change may be indicated by the change of its specific gravity. The specific gravity of the sap of a Sycamore-tree extracted close to the ground, was found by Mr. Knight to be 1.004; at the height of seven feet it was 1.008; and at the height of twelve feet it was 1.012. Or, finally, it may be indicated by properties purely chemical. In the sap of *Fagus sylvaticus*, Vauquelin found water, acetate of lime, acetate of potass, gallic acid, tannin, mucous and extractive matter, and acetate of alumina. [Ann. de Chim. vol. xxxi. 20.] Hence the sap has evidently undergone a certain degree of elaboration, either in passing through the glands of the cellular tissue, which it reaches through the medium of a lateral communication, or in mingling with the juices contained in the cells, and thus carrying off a portion of them;

in the same manner, we may suppose, that water, by filtering through a mineral vein, becomes impregnated with the mineral substance through which it passes.

The next, and indeed the principal part of the process of the elaboration of the sap is operated in the leaf; for the sap no sooner reaches the leaf than part of it is immediately carried off by means of perspiration, perceptible or imperceptible, effecting a change in the proportion of its component parts, and by consequence a change in its properties.

Imperceptible perspiration is an excretion or exhalation of sap thrown off by the eperdermis of the leaf, or other tender parts of the plant, in consequence of the healthy action of the vegetable organs. It is not discoverable by the external senses, as is evinced by the imperceptibility of the process; but it is legitimately inferred from the following fact:—If the branch of a tree is lopped, and the section of the part lopped off covered with mastich, the branch will be found, in the course of a few days, to have lost in weight. This was originally an experiment of Marriotte's, who ascribed the result to the imperceptible escape of sap through the pores of the epidermis. If this experiment is thought to be unsatisfactory, as being made merely on a lopped off branch, take the following, made on a living plant.

Hales reared a Sun-flower in a pot of earth till it grew to the height of three feet and a half. He then covered the mouth of the pot with a plate of lead, which he cemented so as to prevent all evaporation from the earth contained in it. In this plate he fixed two tubes, one for the purpose of admitting the external air left always open, the other for the purpose of introducing a supply of water, but kept always shut, except at the time of watering. The holes at the bottom of the pot were also shut, and the pot and plant weighed for fifteen successive days, in the months of July and August. Hence he ascertained not only the fact of transpiration by the leaves from a comparison of the supply and waste, but also the quantity of moisture transpired in a given time. In a dry and hot day the plant transpired the most, and in a damp and wet day it transpired the least; the mean rate of transpiration being 1lb. 4oz., which is about seventeen times more in proportion than that of the human body. In a hot and dry night without dew it transpired 3oz., in a dewy night it did not perspire at all, in a rainy night, or night of much dew, its weight was increased by 3oz. The surface of the leaves and stem of the plant which was the subject of experiment, was found to be equal to about 5616 square inches; and the surface of the root of the same plant, or of one of the same size, was found to be about 2286 square inches, the latter being to the former in the proportion of two to five, and the absorbing power of the root being, consequently, greater than the transpiring power of

the leaves in the proportion of five to two. But the most remarkable instance of rapid transpiration upon record, is that which is related by Guettard, who found that a small sprig of the Corneil-tree, *Cornus mascula*, transpired in the course of a day a quantity almost the double of its own weight.

Evergreens and succulent plants transpire less than other plants. Yet it is known that succulent plants absorb a great deal of moisture, though they give it out thus sparingly; which we cannot but regard as a wise institution in nature for the purpose of resisting the great droughts to which they are generally exposed, inhabiting as they do, for the most part, the sandy desert, or the sunny rock.

From the whole Hales inferred that transpiration is in proportion to the transpiring surface; temperature, sunshine, and drought promoting it; and cold and wet diminishing, or suppressing it entirely. It is also greatest from six o'clock in the morning till noon, and is least during the night; and upon the same principle it is more abundant in July than in June, and still more so in August than in either of the preceding months; from which last period it begins again to decrease. Yet if at any time it is too abundant through excess of heat or of drought, the plant suffers, and the leaves droop, and do not again revive till the approach of night.

The substance thus transpired by the plant may be obtained by enclosing a bough in a glass vessel of proper dimensions luted to the branch. Its properties have not yet been very minutely investigated. Hales and Guettard could discover in it nothing different from common water, except that in some cases it had the odour of the plant; but Duhamel found that it became sooner putrid than water. But whatever may be the precise character of the chemical composition of the matter of imperceptible perspiration, its discharge from the plant effects indubitably a very considerable modification in the composition of the ascending sap, which is further modified in consequence of what may be called perceptible perspiration, that is an exudation of moisture too gross or too abundant to be dissipated immediately, and hence accumulating on the surface of the leaf. It is very generally to be met with in the course of the summer on the leaves of the Maple, Poplar, and Lime-tree, but especially on the surface exposed to the sun. Its physical as well as chemical qualities are very different in different species of vegetables; so that it is not always merely an exudation of sap, but of sap in a high state of elaboration, or mingled with the peculiar juices or secretions of the plant.

Sometimes it is a clear and watery fluid conglomerating into large drops, such as are said to have been observed by Mr. Millar of Chelsea, exuding from the leaves of the Plantain-tree, *Musa paradisiaca*; and

such as are sometimes to be seen in hot and calm weather exuding from the leaves of the poplar and willow, and trickling down in such abundance as to resemble a slight shower. This phenomenon was observed by Sir J. E. Smith under a grove of willows in Italy, and is said to occur sometimes even [in England. [Introduct. p. 188.] It is glutinous as on the leaf of the lime-tree, or waxy as on the leaves of rosemary, or saccharine as on those of the Orange; or it is resinous as on the leaves of *Cistus creticus*, from which the resin known by the name of *labdanum* is obtained by means of beating them with leathern thongs to which the exudation adheres [Voyage de Tournefort]; as also on the leaves of the Lombardy Poplar, *Populus dilatata*, the exudation from which, Ovid in his metamorphosing flights regards as the tears of Phaeton's sisters, whom he transforms, as it is supposed, into this species of poplar. The tears were now gum.

“Inde fluunt lachrymæ, stillataque sole rigescunt
De ramis electra novis, quæ lucidus amnis
Excipit, et nuribus mittit gestenda Latinis.”—OVID. MET. II. 376.

The leaves of *Dictamnus albus* are said also to be often covered with a sort of resinous substance, and after a hot day, if the air is calm, the plant is even found to be surrounded with a resinous atmosphere which may be set on fire by the application of the flame of a candle. This discovery seems to have been first made by a daughter of the celebrated Linnæus.

The cause of this excess of perspiration has not yet been altogether satisfactorily ascertained, though it seems to be merely an effort and institution of nature to throw off all such redundant juices as may have been absorbed, or secretions as may have been formed beyond what are necessary to the due nourishment or healthy state of the plant, or beyond what the plant is capable of assimilating at the time. But there are cases in which the exudation is to be regarded as an indication of disease, as in that of the exudation known by the Honeydew of the Hop, according to Linnæus; or of the Beech-tree as caused by an unfavourable wind, according to Sir J. E. Smith. [Introduct. p. 189.]

The sap then, in the progress of its ascent from the extremity of the root to the extremity of the leaf, undergoes a considerable change, first, in its mixing with the juices already contained in the plant, and then in its throwing off a portion at the leaf. Perhaps it is also further affected by means of the gases entering into the root along with the moisture of the soil; but certainly, by means of the gases inhaled from the atmosphere into the leaf,—the process of the elaboration of which, we will now attempt to detail.

ELABORATION OF CARBONIC ACID.—Of the several departments of science which have received elucidation from the discoveries of modern chemistry, no one has received it in a greater degree than that which relates to the economy of vegetation. This is attributable chiefly to the introduction and rapid progress of pneumatic chemistry, which opened up to the view of the phytologist the agency of the gases, and laid the foundation of the theory of what has been called, from analogy, the respiration of vegetables. The result of the first experimenters was the discovery of the essential agency of oxygen, or vital air; but it was soon discovered that carbonic acid gas, the fixed air of the earlier chemists, acts a part, not less essential, in this important process. The primary facts that aroused the curiosity of chemists, and led the way to future discovery, were those announced by Priestley, in his experiments on air. About the year 1771 he found that sprigs of mint growing in water and placed over wort in a state of fermentation, became quite dead in the space of a day, and did not recover even when put into an atmosphere of common air. About the same period he found also that a cabbage-leaf which was placed under a glass filled with common air for the space of one night only, had so affected its atmosphere by next morning that a candle would not burn in it, and yet the leaf showed no symptoms of putrefaction. From these facts it was evident that carbonic acid gas was playing a very important part in the economy of vegetable life. Hence the subject was soon taken up by other experimenters. Dr. Percival of Manchester [Manchester Trans. vol. ii.] found that a plant of Mint immersed in water by the root and exposed to a current of atmospheric air mixed with carbonic acid, grew more luxuriantly than a plant of the same species similarly situated, and exposed to a current of pure atmospheric air.

Improving upon this hint, M. Theod. de Saussure [Sur la Veget. chap. ii., sec. 5] made some experiments with a view to determine the dose of carbonic acid gas which, being mixed with atmospheric air, is the most favourable to vegetation. Having taken a number of young plants of pease of about the weight of twenty grains each, he immersed them by the root in glasses filled with water. Thus conditioned, he next introduced them into receivers exposed to the direct rays of the sun, and filled some with common air, and some with different mixtures of common air and carbonic acid gas. In an atmosphere of common air exposed during ten days to the sun they were found to have increased their weight by eight grains. In an atmosphere of pure carbonic acid gas they faded and withered away without any further developement. In an atmosphere containing three-fourths of carbonic acid gas they withered also. But if containing only one-

half they lived seven days ; if but one quarter ten days, augmenting their weight by five grains ; and if containing only one-twelfth of carbonic acid gas, they increased their weight by eleven grains. This was the maximum of its beneficial application.

Hence it follows that carbonic acid gas is of great utility in forwarding the growth of plants vegetating in the sun, if applied to the leaves and branches, in mixture with common air, and in any proportion not exceeding one-twelfth of their atmosphere. But the result is not the same if the plant is placed in the shade ; for in this case the smallest dose of carbonic acid gas in addition to that of atmospheric air is evidently prejudicial. In like manner its agency is beneficial to vegetation if applied to the root, at least in solution with water, or with the moisture of the soil. Plants having their roots in contact with acidulated water were found at the end of a month to have surpassed in dimensions considerably other plants having their roots in contact merely with distilled water. But plants having their roots or part of their roots in direct contact with pure carbonic acid gas are evidently injured by such application. A plant of the Horse Chestnut so exposed died in the course of eight days, without having perceptibly diminished the volume of the enclosed gas that was employed in the experiment ; while plants having part of the root exposed in a similar way to atmospheric air grew luxuriantly, and were found to have diminished considerably the volume of the enclosed gas that was employed in the experiment.

Such are the circumstances under which carbonic acid gas may be inhaled by leaf and stem, or absorbed by the root, beneficially. On this ground M. Decandolle finds an analogy between plants and animals. [Phys. Veg. 1300.] There are certain gases which animals may take into the stomach with impunity if mixed with other bodies, but which they may not take into the lungs without instant detriment or death. Azote, hydrogen, and carbonic acid gas are of this description ; that is, you may take them into the stomach with impunity, as you may Seltzer water, a very wholesome beverage, sparkling with the brilliancy of champagne ; but if you take them into the lungs they are instantly fatal to life. So the same gases absorbed by the root in solution, if not beneficial, are at least harmless ; but if inhaled into the plant in a pure state, whether by leaf, stem, or root, or if even presented for inhalation, they operate a most prejudicial effect. In the former case they are presented to the digestive organs, in the latter case they are presented to the respiratory organs of plants. But it has been discovered that carbonic acid gas is also evolved by plants, at least when vegetating in the shade, or during the night. This is the explication of the fact of the deterioration of the atmosphere of the

cabbage-leaf as discovered by Priestley, who did not attempt to account for it at the time, but left it to be afterwards accounted for by Saussure.

Into a receiver containing atmospheric air only, Saussure introduced plants of *Vicia Faba*, and placed the apparatus in the shade; but at the end of six days, when the experiment was stopped, the atmosphere of the receiver was found by the application of lime water to contain $\frac{11}{100}$ of carbonic acid. Into another receiver, still in the shade, he introduced, with the atmospheric air and the plants, a small quantity of lime water. At the end of six days the atmosphere of the receiver contained $\frac{3}{100}$ of carbonic acid, though much must have been abstracted by the lime. But in both of these experiments the excess of carbonic acid gas found in the atmosphere of the plants, could have been derived only from the plants themselves. Plants, then, vegetating in confined atmospheres evolve carbonic acid gas in the shade, or during the night; and the vitiated state of their atmospheres, after experiment, is owing to that evolution. [Sur la Veg. chap. ii.]

But in this alternate inhalation and extrication of carbonic acid is any part of it assimilated to the plant, or is the quantity extricated always equal to the quantity inhaled? From the continual increase of the substance of the vegetating plant, the assimilation of carbonic acid, or of the carbon which it contains, seems to follow of necessity; and the supply inhaled by the leaves, or absorbed by the root, is thus found to be indispensable to the process of vegetation. For if the carbonic acid that is evolved in the night is withdrawn from the artificial atmosphere as soon as it is formed, the leaves wither and the plant dies. Into a receiver containing atmospheric air deprived of its carbonic acid, in which a pea had been made to vegetate, Saussure introduced a small quantity of lime, placing the receiver over lime water, and exposing the apparatus to the sun. On the second day the atmosphere of the plant had diminished in volume. On the third day the lower leaves began to fade, and on the sixth day the stem was completely stript of its leaves. The atmosphere when examined was found to be vitiated, containing only $\frac{16}{100}$ of oxygen. But there had been an absorption of carbonic acid by the lime, and consequently a previous formation of that acid, the carbon of which could have been derived only from the plant.

The elaboration of carbonic acid gas, then, is unquestionable, and indispensable to vegetation in the sun. But in what state is it actually assimilated to the plant? Is it assimilated in the state in which it is inhaled, or is it previously decomposed? It had been observed by Ingenhouthz that the leaves of plants, if placed in water and exposed to the action of the sun's rays, will evolve a quantity of oxygen gas.

It was afterwards ascertained by Senebier that this process takes place only when the leaves are fresh, and the water impregnated with carbonic acid. For when the water was deprived of its carbonic acid by boiling, or in the course of experiment, there was no more oxygen evolved. But when the water was again impregnated with carbonic acid, the extrication of oxygen recommenced as before. Thus the conclusion is obvious, and the phenomenon satisfactorily accounted for,—the carbonic acid gas contained in the water is abstracted and inhaled by the leaf, and immediately decomposed; the carbon being assimilated to the substance of the plant, and the oxygen evolved.

From the above view of the subject it follows that the decomposition of carbonic acid takes place only during the light of day. How the light acts is not certainly known, but the effect is operated chiefly by means of the leaves, and other green parts, that is chiefly by the parenchyma; for the wood, roots, and petals, with leaves that have lost their green colour, do not seem capable of exhaling oxygen. Hence even the carbonic acid that mingles with the moisture of the soil, and enters the plant by the root, is not decomposed till it has reached the green parts; neither is there any fixation of carbon in the plant except through means of the decomposition of carbonic acid. Yet in the process of the fixation of carbon there seems, according to Saussure, to be also a partial fixation of oxygen, as well as the disengagement of a portion of nitrogen, of which the origin is a matter of doubt. Has it entered the plant with the air of the atmosphere, or mingled with carbonic acid, or with animal substances soluble in the moisture of the soil?

ELABORATION OF OXYGEN.—The first experiments leading to the discovery of the agency of oxygen in the economy of vegetation were those of M. Bonnet of Geneva. His method was to expose the leaves of plants to the sun in an inverted glass vessel filled with spring water; air bubbles began immediately to disengage themselves from the surface of the leaves, and to ascend to the surface of the water. Were they furnished by the water or by the leaves? If the water was deprived of its air by means of boiling, no more bubbles were disengaged; and hence the inevitable conclusion seemed to be, the conclusion that M. Bonnet drew, namely, that they were furnished by the water. It was apparently very logical, but, unfortunately, very erroneous.

The next experiments on this subject were those of Priestley, and the new path he had but just opened up in pneumatic chemistry conducted him to the most important results. On the 17th of August, 1771, he put a sprig of Mint into a quantity of atmospheric air in which a candle had been made to burn till its combustion could be

supported no longer, and found that after confining it till the 27th of the same month the air was again ameliorated, and capable of supporting combustion as before. [On Air, 1774.] Thus the vitiated air was evidently ameliorated by the introduction of the sprig of Mint; and when plants of groundsel and spinach were so introduced, they gave the same result, the process seeming to depend on their being in a state of vegetation. It does not, however, appear that Priestley had yet discovered whether the above result was owing to the abstraction of any thing from the atmosphere, or to the extrication of any thing by the plant. But he discovered afterwards that plants, when placed in water and exposed to the light of the sun, give out what was then called pure or dephlogisticated air—that is, oxygen gas; absorbing and retaining, as he thought, at the same time, and as their proper *pabulum*, what was then called phlogiston. Hence the doctrine of Priestley was, that the air of the atmosphere is ameliorated through means of the process of vegetation, and purged of the impurities with which it is loaded by the putrefaction of vegetable and animal substances; the noxious part being assimilated to the substance of the plant, and the remaining part evolved pure; so that the atmosphere, even of bogs and marshes, is purified and rendered salubrious, or at least less insalubrious, by means of the plants that grow in them, such as the *Confervæ* and Duckmeat, which last thrives, as he says, better in inflammable than even in dephlogisticated air. [On Air, vol. iii. 1789.]

It now became the task of the pneumatic chemists of the day to show what part of this doctrine was true, and what false; that is, to ascertain what this purer air was; whence it came; under what conditions; what was its agency in the economy of vegetation; and whether phlogiston was indeed the proper *pabulum* of the plant. The last of these enquiries has received its answer at the article on **VEGETABLE FOOD**; the rest remain now to be considered.

Ingenhoutz, as we have already seen in the foregoing article, was the first to ascertain that the air exhaled as above is pure oxygen gas. But the subject was taken up about the same time by Spalanzani, Senebier, and M. Th. de Saussure, each adding something corroborative of the fact; yet the researches of M. de Saussure are the fullest and most important. All sorts of water are not equally well fitted for the purposes of the experimenter. With boiled water or distilled water there is no extrication of gas; nor with water holding in solution hydrogen, oxygen, or azote. Yet with water containing but the most minute quantity of carbonic acid in solution the extrication commences immediately; and in proportion to the quantity of carbonic acid which the water contains, in the same proportion is the extrication of oxygen, the greatest proportion of all being from water arti-

ficially charged. Hence it follows irresistibly, that the oxygen extricated has been furnished by the carbonic acid contained in the water, and decomposed by the leaves. Yet the carbonic acid gas which the water originally contained may be exhausted. If you keep continually adding fresh leaves the extrication of oxygen ceases; but if you add fresh water it commences anew. Thus the leaves of plants, placed under water and exposed to the light of the sun, while they decompose the carbonic acid which the water contains, assimilate the carbon and set the oxygen free. They do the same thing also with the carbonic acid gas which is absorbed in solution by the root, and transmitted to them through the current of the ascending sap. Senebier placed two branches of a peach-tree under two recipients filled with water from the same spring, so that the lower portion of the branches projected beyond the recipients, one of them into a vessel containing water impregnated with carbonic acid, and the other into a vessel that was left empty. The former disengaged a quantity of oxygen gas equal to a volume of water weighing 4815 grains; the latter disengaged a quantity equal but to 2535 grains. The increased quantity of the former was furnished, doubtless, by the water absorbed by the base of the branch.

Such is the result in the case of leaves or plants placed in water, and exposed to the light of the sun. But the result is the same if they are placed in atmospheric air, and exposed to the light of day. The experiments of Saussure (*Sur la Vegetation*) are decisive on this point; yet the leaves will not accomplish the decomposition of carbonic acid except under certain conditions. They must be perfectly sound and fresh, and in confined atmospheres they must displace from one-twentieth to one-tenth part of their volume of the air contained in the receiver. If they displace less, the effect is not sufficiently perceptible; if more, there is too little oxygen left. Further, they must not touch the sides of the receiver when placed in the sun, as the heat of the glass might disorganize their structure.

Do any of the other parts of the plant decompose carbonic acid?—Saussure found that the wood, roots, and petals, with leaves that have lost their green colour, do not decompose it. Its decomposition is generally regarded as being effected by the green parts of the plant, as if the green colour were the efficient cause of it, whereas the green colour is rather the effect of the evolution of oxygen, giving predominance to the alkali contained in the leaf, according to the very plausible opinion of Mr. D. Ellis. That some leaves, not green, do still decompose it, may be seen in the example of those of *Atriplex hortensis*, which, even though red, do yet exhale oxygen gas.

But as it was proved by experiment that plants exhale oxygen in the day, so it was also proved that they inhale it in the night. It

remained, however, to be determined whether any part of the oxygen inhaled was assimilated to the plant, or whether plants evolve during the light of day exactly what they inhale during the darkness of night. A *Cactus* of six cubic inches in volume, which had inhaled during the night *four* cubic inches of oxygen, was exposed by Saussure, on the following morning, to the action of the sun's light in a receiver containing 48 cubic inches of atmospheric air deprived of its carbonic acid. In the succeeding evening its atmosphere was found to have augmented by 4.4 cubic inches, but without any accession of carbonic acid; $27\frac{1}{4}$ parts in the hundred being oxygen, as indicated by the endiometer, and the remainder being nitrogen. Before the experiment the receiver contained 10.1 cubic inches of oxygen, and 37.9 of nitrogen: after the experiment it contained 14.28 of oxygen, and 38.1 of nitrogen—the amount of difference, or the quantity of gas extricated, being 4.18 cubic inches of oxygen and 0.2 of nitrogen. In the course of the second night the quantity of oxygen inhaled was equal to $3\frac{3}{4}$ cubic inches; and in the course of the following day the quantity of gas evolved was equal to 4 cubic inches of oxygen, and $\frac{1}{3}$ cubic inch of nitrogen. The experiment was continued with the same plant during seven successive days and nights, and the result was that the quantity of oxygen alternately inhaled and evolved was always diminishing, and the quantity of nitrogen extricated always increasing. When leaves were kept constantly in the shade and in a confined atmosphere, they continued to inhale oxygen slowly till they were saturated, when they would inhale no more. The quantity necessary to their saturation was about one-fourth of their volume, and the time from 36 to 40 hours. Still the quantity of oxygen exhaled during the day was proportional, and about equal to the quantity inhaled during the night, or during the time of the plant's confinement in the shade up to its saturation. When the former quantity was greater than the latter, Saussure regarded it as being probably owing to the decomposition of water in the plant; and when less, we may suppose that it was partly assimilated. But, however this may be, Saussure found that no permanent assimilation of oxygen was effected in the alternate processes of its inhalation and evolution by the leaves, so as to increase materially the quantity of dry vegetable substance.

The inhalation of oxygen seems to depend upon the structure and organization of the leaf; for Saussure found with regard to the *Cactus* what Senebier found with regard to other leaves,—that when they were cut in pieces and pounded in a mortar so as to destroy their organization, and then placed under a receiver filled with common air, no inhalation took place, though they formed carbonic acid gas by the combination of the carbon which they contained with the oxygen

of their atmosphere. Hence it seems probable that the oxygen inhaled by the plant is thus converted also into carbonic acid, and condensed in the parenchyma. But by what affinity is it retained? It cannot be extricated by placing the plant in the *vacuum* of an air-pump, nor by exposing it to a heat without light; but it yields to the action of the light of the sun. The property, then, which plants possess of inhaling and evolving oxygen in the night and in the day is analogous, and seems to be subordinate to that by which they decompose carbonic acid. The green parts which effect the decomposition of the latter effect also the alternate inhalation and extrication of the former, which two operations seem to be the cause, the one of the other.

But although the quantity of oxygen extricated in the day is proportional to the quantity inhaled in the night, yet the specific quantity inhaled is very different in the leaves of different plants. Succulent plants, and plants inhabiting marshes, consume less than most others, and can live long deprived of that part of their nourishment, or with but a small supply. Trees consume in general more than herbs, and trees that shed their leaves more than evergreens. Such, then, is the detail and rationale of the alternate processes of the inhalation and extrication of oxygen by the leaves of the vegetating plant. Do any of the other parts of the plant perform the same functions? They inhale it, or they consume it by the formation of carbonic acid, and its presence seems necessary to their healthy vegetation, but they do not evolve it in any notable quantity.

If a sound and fresh root deprived of its stem is put into a receiver filled with atmospheric air and placed over mercury, it inhales a small portion of oxygen, and hence diminishes the volume of its atmosphere; but it consumes, and hence seems to inhale a much larger portion in the formation of carbonic acid with carbon, which the oxygen of its atmosphere abstracts from the root. Yet the quantity of oxygen that disappears is always less than the volume of the root, because there is now no ascent of sap to carry off the carbonic acid that is formed within it. But if the experiment is made upon roots to which the stem is still attached, they will inhale many times their own volume of oxygen; because the gas thus inhaled is not yet assimilated to the vegetable substance, but is conducted to the leaves in the state of carbonic acid, and there elaborated or given out to the atmosphere. Roots therefore do not evolve oxygen at all.

If the branch of a woody plant lopped off in the spring immediately before the expansion of the buds, is enclosed in a receiver filled with common air, together with a small quantity of water, it will develop its leaves as if vegetating in the open atmosphere. But it will not effect this developement if placed in a receiver filled with nitrogen

or with hydrogen gas. Hence its developement must have been effected by means of the inhalation of oxygen. It will even give out in the sun what it has inhaled in the shade, that is in proportion to the quantity of green vegetable substance contained in its bark.

The agency and influence of oxygen are equally conspicuous in the developement of the flower. The flower-bud will not expand in an atmosphere deprived of oxygen. It inhales oxygen therefore, though it does not evolve it, but replaces what it inhales by about an equal quantity of nitrogen.

The agency and influence of oxygen are in like manner essential to the maturity of the fruit. Saussure introduced a bunch of grapes, not yet ripe, into a globe of glass which he luted by its orifice to the bough and exposed to the rays of the sun. The bunch ripened without having effected any material alteration in its atmosphere. But when a bunch was placed in similar circumstances, with the addition of a quantity of lime, the atmosphere was contaminated, and the grapes did not ripen.

Of the results of the experiments of Saussure, the following is the sum:—The green parts of plants, but especially the leaves when exposed in atmospheric air to the successive influence of light and shade, inhale and evolve alternately a portion of oxygen gas mixed with carbonic acid. The roots, wood, and petals, and in short all parts not green, with the exception of some coloured leaves, do not effect the successive and alternate inhalation and extrication of oxygen. They inhale it, though they do not give it out again or assimilate it immediately, but convey it under the form of carbonic acid to the leaves, where it is decomposed. Oxygen is assimilated to the plant, but not directly, and only by means of the decomposition of carbonic acid, when a very small proportion of it is retained and assimilated along with the carbon. Hence the most obvious influence of oxygen as applied to the leaves is that of forming carbonic acid gas, and thus presenting to the plant elements which it may assimilate; and perhaps even the carbon of the extractive juices absorbed by the root is not assimilated to the plant till it is converted by means of oxygen into carbonic acid.

Thus it appears that oxygen gas, or that constituent part of the atmospheric air which has been found to be indispensable to the life of animals, is also indispensable to the life of vegetables, on both which accounts it seems to have well merited the appellation of *vital air*, by which it was at one time designated; but although the presence and action of oxygen are absolutely necessary to the process of vegetation, yet Saussure has shown that plants do not thrive so well in an atmosphere of pure oxygen, as in an atmosphere of pure or common

air. Plants placed in the former, during a given time, had acquired but half the weight of similar plants placed in the latter, during the same given time. Whence it follows that oxygen, though the principal agent in the process of vegetation, is not yet the only gaseous agent necessary to the health and growth of the plant, and that the proportion of the constituent parts of the atmospheric air is just what it ought to be, as well for the purposes of vegetable as of animal life; being at once an indication both of the wisdom and goodness of HIM by whom it was established; an indication made more apparent if, with Priestley, we regard what may be called vegetable respiration as the means employed by nature to restore the salubrity of the atmosphere which animal respiration contaminates. The experiments of Saussure give a result favourable to the truth of this doctrine, which we cannot help adopting when we reflect upon the great proportion of carbon which the plant is constantly assimilating, while it assimilates but a very small proportion of oxygen, and sets the remainder free. We are aware indeed that Mr. D. Ellis, in his "Treatise on Respiration," has adduced experiments which give a contrary result. But as the accuracy of that result has been questioned, and its validity brought into doubt, by the result of the counter experiments of one of the most celebrated of all modern chemists, namely, that of the experiments of Sir H. Davy, we cannot regard the opinion of Priestley as being yet fairly refuted. [Agri. Chem. 196.]

ELEMENTARY ORGANS.—If the embryo on its escape from the seed and conversion into a plant, as effected by the process of germination, is taken and minutely inspected, it will be found to consist of a root, a leaf or leaves, and an incipient stem, developed in consecutive order. Also, if the plant is taken and dissected at this period of its growth it will be found to be composed merely of an epidermis enveloping a soft and pulpy substance that forms the mass of the individual; or it may be furnished besides with a central or longitudinal fibre, or with bundles of interspersed tubes or fibres, pervading all its parts and giving tenacity to the whole. The above organs are to be regarded as elementary. How have they been generated?

Some phytologists have attempted to account for their formation by supposing the nutritive juices to consist of multitudes of minute and organic fibres, which, being united together by the vegetable gluten, constitute the cellular and tubular tissue, and thus form the mass of the plant. But this supposition, besides being by much too vague, leaves us just where we were before; for still the question recurs, how are the organic fibres themselves formed? and if we admit their existence without asking any questions, we have yet to learn how it is that they are converted into the organs that we call elementary.

M. Mirbel illustrates the origin and developement of these organs as follows:—The cambium, or nutritive fluid, is converted, in the process of vegetation, into a fine and filmy membrane, which he calls membranous tissue, from which the cellular tissue of the pulpy part of the plant is afterwards formed, by means of the foldings and doublings of the original film, so as to present a hexagonal appearance similar to that of the cells of the bee. The tubular tissue he supposes to be in like manner formed out of the cellular tissue, by means of such openings and perforations as may be accidentally effected in the tissue itself, from the bursting of the vertical partitions of the cells, the tubes having no existence till the membrane is lacerated. [Traité d'Anat. Veg. liv. i. 56.]

We believe this hypothesis to be unfounded in all its parts.—First, because we have, by hypothesis, to regard the cells as being hexagonal in their original form, and separated merely by a single partition, as well as all composed, even in the aggregate, of a single and individual membrane; whereas it has been shown by Dutrochet that the cells are originally distinct globules, assuming a pentagonal or hexagonal shape according to the pressure of surrounding organs, and having their partitions double wherever their sides cohere. [Recherches Anat. 11.] Secondly, because, if the tubes are generated in the manner here supposed, that is, by the accidental bursting of the partitions of the cells, it will be difficult to account for the known regularity with which they are specifically formed, as in the leaf-stalk of plants in general, and in the stipe of the Ferns. The only circumstance giving plausibility to the conjecture is that of the occasional occurrence of a transverse diaphragm interrupting the continuity of the small tubes, which we cannot regard as being altogether a legitimate proof of their cellular origin. Thirdly, because, if we even admit its legitimacy, as M. Dutrochet seems to do, we shall still have to account for the formation of the *tracheæ*, which retain no traces whatever of a cellular origin, and are besides twisted in a spiral direction throughout the whole of their extent. This to M. Mirbel presents no difficulty, but to M. Dutrochet it presents a difficulty which he cannot surmount, and which he regards as a great mystery. [Recherches Anat. 18.]

After all, the molecular hypothesis of M. Raspail seems better calculated to account for the phenomena of the formation of the elementary organs than any other hypothesis with which we are acquainted. On the evidence adduced by M. Dutrochet we cannot but regard the cellular tissue as composed of distinct cells, which are enlarged vesicles that have sprung from a primitive molecule endowed with the power of producing its type, and hence with the power of

producing a cellular tissue. Out of this M. Raspail would rear the superstructure of the whole plant. [See DEVELOPEMENT OF THE VEGETABLE OVULUM.] But why may there not exist also in the nascent embryo, molecules calculated to extend themselves longitudinally, and to form fibres, tubes, or vessels, whether simple or spiral? We think the case receives illustration from the phenomena of the animal fabric. Is not the molecule in which the heart and blood-vessels originate, specifically different from the molecule in which the brain and nerves originate, and has not each a mode of developement peculiar to itself? If so, we may then say of the vegetable fabric—is not the molecule in which the tubes originate specifically different from the molecule in which the cells originate, and has not each a mode of developement peculiar to itself? The primitive and specific molecule proper to each organ pre-exists already in the infant embryo, and is kept in its due position, or is brought to it, either by the ordinary affinities of common matter, or by the more influential affinities or energies of Life.

Hence, by the due assumption and assimilation of aliment, and under the agency of the same affinities, the cellular molecule develops cells, and the vascular molecule develops tubes, simple or spiral, as the case may be. If you say that many tubes exhibit traces of transverse diaphragms, and thus give indication of a cellular origin, it may be admitted that such tubes have been made up of a series of elongated cells generated not at random, but by a mode of developement from which they cannot deviate. Neither does the annual plant, nor the annual shoot of the perennial plant, grow to bulk merely at random. Internally, the several organs always occupy their proper and specific places. Externally, the body of the plant or shoot is bounded, and moulded into a definite and specific form, by a peculiar and appropriate envelope or integument, which, in its earliest stage of growth, is a fine, delicate, and simple pellicle answering to the description of an elementary organ; but which, in its future stages, is often found to consist of several layers, giving it a claim to be regarded as a composite organ. Its description, together with the theories concerning its formation, will be introduced under the head of the term EPIDERMIS,—which see.

ELEMENTARY PRINCIPLES.—The simple and indecomposable substances to which vegetable bodies may be reduced by means of chemical analysis, are the elementary principles of plants. They are chiefly carbon, oxygen, and hydrogen, with a portion of azote in some particular tribes.

EMBRACING LEAF.—A leaf, the base of which invests the stem or branch on which it grows, is in the language of botany an *Embracing leaf*.

EMBRYO.—The embryo is the germ or primordial rudiment of the future plant as existing in the seed. See DISSECTION OF SEEDS.

EMENDATIONS OF SYSTEMS.—It was scarcely to be expected that the system whether of Linnæus or of Jussieu should have come from the hands of its author, in a state so very finished, and so very perfect, as to be incapable of all further improvement. Hence the alterations which have been introduced into the two systems respectively by the disciples of either leader. It is to be recollected, however, that all alterations are not emendations. Do they tend to make any thing plainer? Do they facilitate the investigations and lessen the labours of the student? Are they in keeping with the principles on which the system rests, giving a fuller extension to the views of the original founder, and not throwing both the architect and his building into the shade? If they possess these qualities in a conspicuous degree, they may be regarded as *Emendations*; but if not, we think they are better entitled to the appellation of *Innovations*. The alterations which Thunberg and Withering inflicted upon the system of Linnæus were not much approved of by botanists in general; and some of the alterations which have been inflicted on the system of Jussieu, even by botanists of high reputation, do not seem to have met with the cordial approbation of the best qualified judges.

I. M. Decandolle, professor of botany at Geneva, an acute and skilful systematist, exhibits the first example of innovation, or, if you will, of alleged emendation. In his *Théorie Élémentaire* and *Prodromus*, he substitutes the term Exogenæ in place of Dicotyledons, and the term Endogenæ in the place of Monocotyledons and Acotyledons; but we can see no advantage that is gained by the substitution. MM. Desfontaines and Daubenton had already shown that Dicotyledonous plants are exogenous, and Monocotyledonous plants endogenous, and Jussieu was well enough aware of the fact. The new terms, we admit, were not yet imposed; but if exogenous and endogenous are respectively identical in their extent with Dicotyledonous plants on the one hand, and with Monocotyledonous plants on the other, whence could the advantage of the substitution come? And if you extend the meaning of endogenous so as to make it include Acotyledonous plants also, we question the legitimacy of the extension, and contend that their endogeneity is not at all of the same character with that of the Monocotyledons. Besides, the change of terms leaves the affair of method precisely where it was, while it has the effect of keeping Jussieu and his divisions too much in the background, as well as of giving room for the remark that the principles of the system are departed from. It is enough if the novel terms are introduced to the aid and illustration of the terms of Jussieu, but not

to the entire exclusion. Neither do the names imposed upon the minor divisions seem to us to be any improvement. In what respect is *thalamifloræ* better than *hypopetalæ*, or *calycifloræ* than *peripetalæ* or *epipetalæ*? If neither one set of terms nor the other is imposed in strict conformity to the anatomical structure of flowers, why exclude one term that is faulty merely to make room for the introduction of another term that is faulty also? It may be true that the stamens and corolla have always the same insertion; it may be true that, in strictness of anatomical speech, their real insertion is always on the *torus*; but as botanical writers seem satisfied to describe them by their apparent insertion, we are of opinion that, unless some very obvious advantage were to follow from it, the nomenclature and divisions of Jussieu ought not to be disturbed. Finally, the division of Acotyledonous plants into *Cryptogamæ* and *Cellulares* does not seem to us to be a sufficiently scientific distribution of the group, because the *Cellulares* are still, in fact, *Cryptogamous*, as well as the *Cryptogamæ* themselves. But his *Dichlamydeæ*, and *Monochlamydeæ*, and *Achlamydeæ*, we regard as improvements, as affording a convenient ground of subdivision, and imposing names upon distinctions involved, though not designed, by individual terms in the arrangements of Jussieu.

II. A learned professor of botany among ourselves, of high talent and reputation, exhibits the second example of innovation. In his "Introduction to the Natural System of Botany" he sets out with dividing vegetables into two grand groups, which he calls classes, the *Vasculares* and the *Cellulares*, or flowering and flowerless plants. The terms vascular and cellular stand sufficiently in opposition to one another to form the ground of a legitimate division; but the feature upon which they rest is not more important than that of cotyledons, or the want of them, and gives them, consequently, no apparent claim to supersede the terms of Jussieu. Besides, the terms employed by the Professor are, perhaps, not altogether so correctly descriptive of their respective groups as those employed by Jussieu. The former are of the same extent with cotyledonous plants, and the latter are presumed to be of the same extent with acotyledonous plants. But it is very well known that this is not the fact, as will appear from the following subdivisions into which the *Cellulares* are distributed by the Professor himself. 1st, The *Vasculares* are subdivided into the *Exogenæ* and *Endogenæ* of M. Decandolle,—terms which are substituted in place of the *Dicotyledons* and *Monocotyledons* of Jussieu, though we confess that we cannot see the utility of the substitution. The *Exogenæ* are next divided into *Angiospermæ* and *Gymnospermæ*. The former seems to be of a dimension too unwieldly, as containing the polypetalous, apetalous, and diclinous plants of Jussieu, in no less

than 165 orders, together with the monopetalæ, in 61 orders more ; while the latter seems to be of a dimension too small, as containing only 2 orders, making it nearly the same thing in practice as if they were all angiospermous still ; so that the peculiarities which the subdivision involves, though important in themselves, and founded undoubtedly in nature, do not seem to us to be of any great utility as forming the ground of a systematic arrangement,—at least, without having the larger subdivisions subdivided again, in a sufficient number of groups still smaller. The two main divisions of the Exogenæ are called tribes, and yet the orders belonging to them are called tribes also. If this is a fault, it is one that admits of an easy remedy, which, we think, the term family would furnish. The Endogenæ are subdivided into petaloideæ with minor groups and glumaceæ, a subdivision which presents to our notice nothing exceptionable. 2nd, The Cellulares are subdivided into Filicoideæ, Muscoideæ, and Aphyllæ, which might be a good enough division of the class provided it went by the name of Acotyledonous. But as the Cellulares are presumed to have no vascular system, we do not see how they can be legitimately made to include the Filicoideæ, the very diagnosis of which is that they are “flowerless plants, with a stem, *having a vascular system* and distinct leaves.” [Introd. to Nat. Syst., p. 310.] The Vasculares are the flowering plants, the Cellulares are the flowerless plants. The antithesis is good in fact, but it can scarcely be said to be good in expression. Flowering and flowerless are not so happily opposed to one another as powerful and powerless are, that is, the participle and the adjective, owing to their grammatical peculiarities, do not form a neat or laudable contrast. We admit that this want of systematic symmetry is but a mere trifle after all, though it ought not to have occurred in the work in question. To evade the objection arising from the vascularity of many of the Cellulares, it has been said that they are furnished merely with ducts, but not with spiral tubes. This may be all quite true, yet what are ducts but vessels ?

We do not pretend to give advice to these able and eminent botanists, knowing that nothing short of the experience of the most profound adept is sufficient to qualify or to entitle any one to do so ; neither do we expect from *our* speculative demonstrations a result subversive of *their* practical arrangements. We merely claim the privilege of expressing and recording our sentiments, and of stating what seems to us to be exceptionable in the above novel methods ; or, at the least, not calculated to facilitate the study of the natural system, or to improve the method of Jussieu, which stands in need of no violent innovations to give it in appearance the pre-eminence which it possesses in reality. It requires merely a drawing out of the resources

which it has within itself, or the addition of such supplementary distinctions as the progress of botanical knowledge may have rendered necessary. In defence of innovations, it has been said that the system, though altered, is still but the system of Jussieu after all. True; for as there is but one system that is natural, and that system Jussieu's, botanists cannot conjure up a new one at their pleasure. "Other foundation can no man lay than that is laid,"—though he may disguise the old one, and build upon it a totally different structure, like Thunberg and Withering in their artificial arrangements. They counted stamens and pistils, as did their great master Linnæus, but they mutilated his system and substituted one of their own in its room.

But although we do not approve of the change of nomenclature, or of the innovations upon system introduced, whether by M. Decandolle or by Dr. Lindley, yet we are very far from wishing to depreciate the merit of their respective works;—works exhibiting such abundant proofs of extensive research, of accurate discrimination, and of just and logical deduction in the tracing of natural affinities, as will enable their respective authors to maintain that high station in the scale of botanical eminence which they had previously reached, and will doubtless secure to them a lasting reputation. If there should be a difficulty in unlocking Dr. Lindley's orders, even with the help of his analytical key, it is to be recollected that Dr. Lindley has never once attempted to disguise or to palliate difficulties, but rather to impress upon the mind of his reader the absolute necessity of unremitting exertion.

" Nil sine magno
Vita labore dedit mortalibus."—HORACE, SAT. IX. Lib. i.]

His introduction may not be adapted to the desultory application of the sciolist or trifler, but it will be found to be a very valuable present to the patient and indefatigable student who is content to encounter difficulties, and willing to obtain knowledge at the expense of labour.

If we were called upon to say how it is at all practicable to adapt the system of Jussieu to the present state of botanical knowledge without innovating upon its principles, in external appearance at least, our reply would be, that availing ourselves of whatever we may find in the works of the above-mentioned authors, or of others, calculated to illustrate the character of the groups, or to give perspicuity to the arrangements of Jussieu, and retaining not merely the foundation, but the identical structure which he reared upon it, we would venture to add to it a trifle more of extension, or of filling up, in the style and manner, as much as may be, of the original edifice, that the

masterly traits of the hand of the founder may never be lost sight of. It will be seen that this adaptation can descend no lower than to the distribution of classes. The orders and their arrangement will be continually changing as long as there shall remain new plants to be collected, or new affinities to be discovered; but we do not see the necessity of any violent alteration in the circumscribing of the larger groups. All that we regard as necessary is comprised in the following tabular sketch, giving, as we fancy, a neatness of outline to the higher divisions of the system, by the formal introduction of a very few distinctions that were either implied in it from the beginning, or rendered necessary by the progress of analytical research.

Vegetables.

GROUP I. COTYLEDONOUS PLANTS. — Vascular with spiral tubes;—phænogamous,—bisexual,—angiospermous.

DIVIS. I. DICOTYLEDONS.—Growth exogenous,—circumferential.

Subd. I. Dichlamydeæ.—Floral envelope double,—a calyx and corolla.

Sect. I. Polypetalous.

Class I. Hypopetalæ.

II. Peripetalæ.

III. Epipetalæ.

Sect. II. Monopetalous.

Class IV. Hypocorollæ.

V. Pericorollæ.

VI. Epicorollæ.

1. Synantheræ.

2. Corisantheræ.

Subd. II. Monochlamydeæ.—Floral envelope single,—perianth or presumed calyx.

Sect. I. Apetalous.

Class VII. Hypostamineæ.

VIII. Peristamineæ.

IX. Epistamineæ.

Sect. II. Anomalous.

Class X. Diclines.

1. Angiospermæ.

2. Gymnospermæ.

DIVIS. II. MONOCOTYLEDONS. — Growth endogenous,—central. Floral envelope a perianth, often in two rows; sepaloid, petaloid, or glumaceous.

Class XI. Monohypogynæ.

XII. Monoperigynæ.

XIII. Monoepigynæ.

GROUP II. ACOTYLEDONOUS PLANTS.—Cellular, or, if vascular, without spiral tubes?—Cryptogamous.

Class XIV. Ductulosæ.—Cellular, with interspersed ducts, —seminiferous.

XV. Eductulosæ.—Wholly cellular;—gemmiferous.

Thus the whole of the vegetable kingdom is divided into two grand groups, without any sacrifice of the technical language of Jussieu. For although his system does not actually exhibit a division into Cotyledonous and Acotyledonous plants, yet it evidently and essentially involves that distinction. Hence the introduction of the former term is only the completing of the contrast which was already implied in the use of the latter. We have thought it right to put the group designated by the positive term first, because the student cannot be supposed to know well what is meant by an acotyledonous plant till he has already found out what is meant by a cotyledonous one; and although the term acotyledonous is negative in its composition, yet the character which it points out to the learner is positive, namely, that of the want or absence of cotyledons; so that the division is legitimate in whatever aspect you survey it. But we do not rest content merely with a correct antithesis. We avail ourselves of all the lights, old and new, that have been thrown upon either group. In the former we recognise its vascular, its phænogamous, its bisexual, and its angiospermous characters; and in the latter, its cellular, but partially vascular and cryptogamous characters. We accept them as auxiliaries illustrative of the respective groups, but we do not discard the old terms of Jussieu, merely that we may use them as synonyms to new ones of our own.

The first grand group Jussieu distributed into two divisions, dicotyledonous and monocotyledonous—divisions that are well contrasted and cannot be improved. All that we add is merely their exogenous and endogenous characters respectively.

The division of the Dicotyledons we subdivide into Dichlamydeæ and Monochlamydeæ, terms invented by Decandolle, but not introducing a new principle that was not already to be found in the system, and in full and actual operation. For although the terms were not there, the things signified by them were there, and were made available to the purposes of arrangement, though not designated by individual names. The former term is equivalent to the double envelope of calyx and corolla, and the latter to the single envelope or perianth. They are all exogenous.

The division of the Monocotyledons Jussieu did not subdivide into

any minor groups, and neither do we. We notice merely the leading peculiarities of the perianth. They are all endogenous.

In the whole of the above divisions or subdivisions, the classes are uniformly founded on the mode of the insertion of the stamens, as being hypogynous, perigynous, or epigynous. For although a novice might fancy that the principle of arrangement changes with the change of termination in the names that have been imposed upon the classes, yet the more experienced botanist knows that the origin of the stamens and corolla is uniformly and universally the same, and that whatever is predicable of the one in that respect, is predicable also of the other; and although the introduction of these distinctions, at least in the circumscribing of classes, has been denounced as being wholly and essentially artificial, as well as utterly and absolutely extravagant, on the score of its exhibiting a want of due economy in the husbanding of resources, and an improvident expenditure of botanical ammunition that might have been rendered available in the construction of orders and of genera. [Roscoe on Arrangements, Linn. Trans., vol. XI. part i., or Phil. Mag. and Annals, N. S., vol. VII.], yet this want of due economy is altogether imaginary. There is an abundance of characters remaining for the constructing of orders and of genera, as resulting from other and important peculiarities discoverable in the form, structure, or position of the stamens, pistils, ovary and ovula, fruit, seed, embryo, or from additional and similar peculiarities discoverable in other parts of the flower or plant. Hence the distinctions founded on the mode of insertion, instead of being an objection to the method of Jussieu, are only a proof of its excellence, in the facility which they give to investigation, and in their applicability to the whole of the grand group of cotyledonous plants, whether dicotyledonous or monocotyledonous, dichlamydeous or monochlamydeous, polypetalous, monopetalous, or apetalous; so that by retaining the terms and divisions of Jussieu, we are, as it were, always in company with him, or meeting with him at every turn. Hence, also, the plan of procedure and the enquiries to be made by the student are always the same in all the divisions of the group. Is the plant cotyledonous or acotyledonous; is it dicotyledonous or monocotyledonous; is its floral envelope, single or double; is the flower polypetalous, monopetalous, apetalous, or anomalous; are the stamens hypogynous, perigynous, or epigynous? This analysis brings him down to the several classes of the first grand group, which, from their number, are prevented from being surcharged with too many tribes or families. When botanists are prepared to introduce classes founded upon the principle suggested by Dr. Brown in his "*Botany of Congo and of Terra Australis*," that is, the principle of combining into an aggregate

group, to be called a class, such orders as are very closely allied, not merely by a single trait, but by the sum of their affinities, enabling us to dispense with the use of empirical characters entirely, then it will be time enough to discard the classes of Jussieu. The objections to which they are liable apply with equal force to the divisions by which they have been superseded in the works of the above systematists; all of them being clogged with anomalies that will puzzle the learner and impede him in his career, let him embrace what system he will.

The second grand group Jussieu did not divide into any minor groups, but introduced merely as a single class. Yet there is an evident demand for such a division, both from the number of species which the group contains, and from the peculiarities of structure which several of its tribes display. We adopt a division founded upon anatomical principles, and indicated by features sufficiently obvious, as well as designated by terms which, though novel, are peculiarly appropriate, namely, the *Ductulosæ*, or cellular plants with ducts, but without spiral tubes, as it is said; and the *Eductulosæ*, or plants wholly cellular; the former propagated, perhaps, by seeds, the latter by gems or sporules. The above terms appear to have been originally introduced by Mr. Arnott, of Edinburgh, and seem to us to be quite unexceptionable. [Encyc. Brit., Art. Botany.] The groups which they designate we would erect into classes, the number being still fifteen; for though we have thus split one of Jussieu's classes into two, for reasons that to us seem valid, we have elsewhere run two of his classes into one—the *Epicorollæ synantheræ*, and *Epicorollæ corisantheræ*, for reasons that seem equally valid, by reducing the peculiarities to sections. Beyond this our remarks do not extend. It is the part of the experienced and practical botanist to reduce classes to orders, or to suborders, if necessary, and to construct their diagnosis; or rather, perhaps, by reversing the process and advancing in the line of ascent, to reduce orders or suborders to classes; and to the experienced and practical botanist we are content to commit the task.

ENDOCARP.—The endocarp is the putamen or shell immediately investing the seed or kernel of stone fruit. [See **PERICARP.**]

ENDOGENOUS.—Plants whose growth is effected by increments added to the centre, as in the case of the Palms, are said to be endogenous. They are all Monocotyledons.

ENDOSMOSE.—A term introduced by M. Dutrochet, signifying a rush inwards, as applicable to the strong impulse by which a less dense fluid passes through animal or vegetable membrane, to a more dense fluid; and hence applicable to the impulse by which the moisture of the soil enters the spongiolæ of the root.

EPICARP.—The epicarp is the external cuticle of stone fruit. [See **PERICARP.**]

EPIDERMIS.—The epidermis, a term borrowed from the anatomy of animals, is the external envelope or integument of the plant extending over its whole surface, and covering the root, stem, branches, leaves, flower, and fruit, with their appendages, excepting only the summit of the pistil, and surface of the spongiolæ. But although it is thus extended over almost the whole surface of the plant, it is not of the same tenuity throughout. In the root and trunk it is a tough and leathery membrane, or it is a crust of considerable thickness; while in the leaves, flowers, bud, scales, and tender shoots, it is a fine, colourless, and transparent film, not thicker than a cobweb. It is colourless, however, only when detached; for when adherent it assumes the colour of the parts immediately beneath it. Hence the green colour so prevalent in the leaf and tender shoot, and the beautiful variety of hues displayed in flowers and fruits.

Duhamel, who seems to have been the first to study its structure, minutely describes it as being formed of a multiplicity of fine and delicate fibres placed in a parallel direction, and inosculating at regular intervals so as to constitute a net-work, the meshes of which are filled up with a thin and transparent pellicle, and the membrane thus formed being single, as in the epidermis of the leaf; or divisible into several layers, as in that of the Paper Birch, *Betula papyracea*, in which you may count six or more. [Phys. des Arb. liv. i. chap. 2.]

Saussure the elder inspected it as it occurs in the leaves and petals of Jessamine and Fox-glove, and describes it as constituting a bark composed of two layers, the interior layer being net-like, and interspersed with a multiplicity of what he calls cortical glands, and the exterior layer being totally destitute of organization. [Observ. sur l'Ecorce de Feuilles.]

Hedwig describes it as forming a net-work of fibres that consists of two distinct but adherent *laminæ*; but he regards the cortical glands of Saussure as being merely pores or apertures perforating the pellicle that fills up the mesh. [Tracts relative to Botany. London, 1805.]

Camparetti describes it as consisting of a net-work of fibres ascending in an oblique direction, and forming hexagonal meshes of various sizes and positions, the area of the meshes being occupied by opaque or transparent points of an oval or roundish figure, that seem to be somewhat inflated, as if filled up with air or water. He studied it chiefly as it occurs in the leaves of succulent plants. [Senebier, Phys. Veg.]

Such is the result of the observations of the most distinguished of our earlier vegetable anatomists. Their descriptions do not indeed tally quite so completely as could be wished, but an exact coincidence

was not to be expected in the description of an organ that differs so much in different species of plants, and even in different parts of the same plant. They agree in all that is essential—namely, in representing the epidermis as composed of a net-work of fibres consisting of one or more layers, and the meshes as being filled up with a fine pellicle in which there is often discovered a peculiar area connected with the general net-work, and exhibiting in the centre the appearance of minute glands or pores, or inflated points. Whoever will be at the trouble to repeat the observations will find the descriptions to be sufficiently correct; except that the net-work of fibres is merely the dissepiments of compressed cellules or molecules, and the pores or openings, the stomata of modern phytologists. Still the investigator may meet with modes of structure different from any that have yet been specified. Nature loves to luxuriate in varieties; and further varieties have been, accordingly, met with. Mr. F. Bauer, of Kew, describes the cuticle of *Doryanthes hastata* Corrêa as consisting of two or three stories of cells laid one above another, and exhibiting in their aggregate aspect a resemblance to that of a honey-comb. The epidermis of the petals of the snow-drop coincides pretty nearly in appearance with that of the cuticle of *Doryanthes*; and the epidermis of the inner surface of the petals of *Crocus vernus* presents the similitude neither of a net-work of fibres nor of an assemblage of cells, but of a thin and individual layer of parallel and tangent reeds of unequal lengths, interspersed with multitudes of minute and shining points, and resembling a front view of the false pipes of an organ.

Finally, in the permanent parts of woody and perennial plants, the epidermis often exfoliates, and in such parts it is again regenerated, even though destroyed by accident. But in herbaceous plants, and in the leaf, flower, and fruit of other plants, it never disengages itself spontaneously, and is never again regenerated if once destroyed. How has the epidermis been originally formed?

The pellicle constituting the vegetable epidermis, like the pellicle constituting the animal epidermis, has generally been regarded as a membrane essentially distinct from the parts which it invests, as well as generated with a view to the discharge of some particular function. Thus, for every living being, whether animal or vegetable, nature has specifically provided a peculiar envelope or covering such as its wants may require: for the animal a skin with its epidermis, for the vegetable a bark with its epidermis; or, as in the case of some certain subjects, an epidermis merely.

Some phytologists, however, have viewed the epidermis in a light altogether different, and have regarded it as being the effect of mere accident or position,—that is, as being nothing more than a scurf

formed on the exterior of the pulpy parenchyma, and indurated by the action of the air. This was the opinion of Grew and Malpighi, which, though it does not seem to have ever met with any very general reception, has been, however, revived of late years by M. Mirbel, who, professing to be dissatisfied with the analogy that has generally been thought to exist between the epidermis of the animal and the vegetable, contends that the latter is nothing more than the indurated surface of the parenchyma, from which it differs only in such circumstances as are occasioned by position. If it is more or less transparent,—if it is tougher or firmer in its texture than the parenchyma or any of its parts, it is only because it is constantly exposed to the influence of light and air, and to the contact of such bodies as float in the atmosphere; but it is not to be regarded as constituting a distinct organ or membrane, or as exhibiting any proof of its being analogous to the epidermis of animals. [Trait. d' Anat. et de Phys. Veg. i. 87.]

Such is the substance of M. Mirbel's opinion, to which he is aware that objections may still be urged: for it may be said, If this is the true origin of the epidermis, how comes it to separate so easily from the interior parts in the spring? To this objection M. Mirbel furnishes the following reply—namely, that its facility of detachment is owing to the disorganization occasioned in the epidermis by means of its exposed position, which has even the effect of ultimately detaching it from the plant altogether, as may be seen in the instances in which it bursts and exfoliates when it is not able to expand in proportion to the interior parts; and thus M. Mirbel presumes that he has established his position. But this is by no means the most formidable objection to which his hypothesis is liable; for if it be true that the epidermis is nothing more than the pellicle formed on the external surface of the parenchyma, indurated by the action of the air, then it will follow that an *epidermis* can never be completely formed till such time as it has been exposed to that action. Yet it is known that the epidermis exists in a state of complete perfection in cases where it could not possibly be affected by the external air. If you take a rose-bud, or bud of any other flower, before it expands, and strip it of its external covering, you will find that the petals and other enclosed parts of the fructification are as completely furnished with their epidermis as any other parts of the plant, and yet they have never been exposed to the action of the air. The same thing may be said of the epidermis of the seed while yet in the seed-vessel, or of the root, or of the Paper Birch, which still continues to form and to detach itself, even though defended from the action of the air by the exterior layers. In herbs, and in the annual parts of woody plants, such as the leaves and flowers, the epidermis never detaches itself at

all; which fact M. Mirbel adduces as an additional argument in favour of his hypothesis, though to me it seems an argument against it: for if the air produces such violent effects upon the trunk and branches of woody plants, why should it not produce similar effects upon the stem and branches of other plants, or upon other parts of the same plant? Till a satisfactory answer can be given to these questions, it is impossible to admit the hypothesis of M. Mirbel.

But so far is the action of the external air from being the cause and origin of the epidermis, that it is even detrimental to its formation. For the re-production of a part that has been destroyed, in cases capable of re-production, is always more easily effected if the wound is covered closely up. Hence it is extremely improbable that the epidermis is merely a modification of the external surface of the parenchyma, effected by the action and influence of the air. On the contrary, we regard it as a distinct organ originating in a secretion thrown out by the cells of the parenchyma, and deposited upon the surface, where it concretes into a fine pellicle, composed of united molecules, even while the plant is yet in embryo, for the very purpose of protecting it from injury when it shall have been exposed to the air in the process of vegetation. Its growth or developement is accordingly found to keep pace with that of the plant which it invests as a sheath, extending itself in its superficial dimensions, by the introsusception of new molecules, and accommodating itself with wonderful facility to the expansion of the interior parts, as may be seen in large trees and fruits of rapid growth. Its expansion is circumscribed, however, by certain bounds or limits which it cannot pass; for when vegetation is too rapid, or when the parts have become indurated with age, it refuses, or is unable, to expand further, and consequently cracks, as in the bark of aged trees, or Melons of luxuriant growth, the fissure being for the most part longitudinal, though sometimes, as in the Cherry-tree, horizontal. It is also much more capable of expansion in some trees than in others, and remains longer smooth; and where it does not expand freely, it is thought to retard, in some degree, the developement of the interior parts.

With regard to the disavowed analogy between the animal and vegetable epidermis, it is of no consequence to the above argument whether it holds good or not. But there are several respects in which an analogy between the two cuticles is sufficiently striking: they are both capable of great expansion in the growth of the subject; they are both easily regenerated when injured (with the exceptions already stated), and seemingly in the same manner; they are both subject, in certain cases, to a constant decay and repair; and they both protect from injury the parts enclosed.

EPIGYNOUS.—Stamens that originate apparently in the ovary or pistil, as in the natural order of the Orchideæ, are said to be *epigynous*.

EPIPETALOUS.—Stamens that originate apparently in the petals, as in the genus *Veronica*, are said to be *epipetalous*.

EQUIVOCAL GENERATION.—It was long a vulgar error, countenanced even by the philosophy [Theoph. *Περὶ φυτῶν Ἀιτιῶν. το. Α.*] as well as by the poetry of the times, that vegetables do often spring up from the accidental mixture of putrid water and earth, or of other putrid substances, in the manner of what was called the equivocal generation of animals :—

“ Ver erat eternum, placidique tepentibus auris
Mulcebant Zephyri natos *sine semine* flores.”

OVID. MET. Lib. i. 106.

or, at the very least, it was alleged that the earth contains the principles of vegetable life in itself, which, in order to develope, it is only necessary to expose to the action of the air.

The former alternative of the error has been long ago refuted, and as I believe eradicated, no one now contending for the doctrine of vegetable generation from putrefaction; but the latter alternative, though it has been also refuted, has not yet lost its hold of the minds of the unlearned. The farmer still believes, and will still tell you, that the earth throughout its whole mass teems with the rudiments of vegetable life, or at any rate of all such plants as give annoyance to the cultivator, which it will develope without the sowing of any seed, if only exposed to the action of the air; alleging in support of his opinion, that earth dug up from any depth, and thrown in heaps upon the surface, will immediately and spontaneously begin to send up a crop of young weeds. But the fallacy of this argument is easily exposed; for, in the first place, the roots of such plants as are near to the earth thus exposed will extend themselves around its edges, and make encroachments in the lower part of it; and, in the next place, the seeds of plants, whether near or at a distance, will be conveyed to it by the winds, or by cattle, or by birds, and so furnish the upper part of it with a crop also: hence the argument is good for nothing. Let the experiment be made where the earth shall be perfectly insulated, except from light, air, and water, and let the result be marked. This was done long ago by Malpighi, who, having procured some earth that had been dug up from a great depth, enclosed it in a glass vessel, over the mouth of which he placed several folds of silk, so as to admit air and water, but to exclude all such small seeds as might be wafted on the winds. The result was, that no plant came up.

[Anat. Plant. Pars Altera, 92.] Hence we conclude with Malpighi that the earth produces no plant without the intervention of a seed, or of some species of vegetable germ deposited in it by nature or by art. [See Keith's Physiological Botany.]

After all, it appears that there are still some writers claiming the appellation of philosophers, who contend for the fact of what has been called *equivocal generation*, whether as respecting plants or animals; or at the least they regard the question as not being yet fairly set at rest; alleging in support of the doctrine the acknowledged production of animalculæ, and of some of the Mucors and Confervæ, in conditions in which the supposed presence of germs is attended with manifold difficulties. [Sketches of Phil. of Life, 37.] The difficulties in question must no doubt be admitted; but after the very satisfactory experiments of Redi with regard to animals, and of Malpighi and others with regard to vegetables, in refutation of their equivocal origin, it may be inferred, as we should think, with safety, that the acknowledged cases of doubt are still analogous to the general rule.

ERGOT.—The most mysterious of all the maladies attacking the cereal grasses is that of the *Ergot* or *Spur*. It is a firm, compact, and horn-like substance, white or grey within, and black, with a tinge of violet, without. It issues from between the glumes, and occupies the place of the grain; or it is a prolongation of the grain, grooved and furrowed, and elongated to the extent of an inch. It is found most frequently on rye, but on almost all grains, particularly in barren soils. Bread made from grain much affected by it is extremely unwholesome, and apt to generate dangerous diseases, more especially gangrene of the extremities; yet, used *secundum artem*, it is medicinal. There have been many contradictory opinions concerning its origin; some presuming that it comes from the puncture of insects, though it comes where there is no appearance of puncture; others, from default of fecundation, but without proof; and others, from nobody knows what. Mr. Francis Bauer seems to have regarded it as being merely a morbid swelling of the ear, not at all connected with the growth of a *Fungus*. [Smith's Introd. 348.] But Decandolle, who has investigated the subject more recently, maintains that it is a parasitical *Fungus*, to which he gives the name of *Sclerotium Clavus*. [Phys. Veg. iii. 1457.]

ETIOLATION.—Plants are liable to a morbid or diseased affection, originating in various causes, which entirely destroys their verdure, and renders them pale and sickly. This is called *etiolation*,—the *etiolement* of French writers, and may arise merely from the want of the agency of light, or of the due evolution of oxygen, as may be seen

in the case of plants placed in dark rooms, or between great masses of stone, or in the clefts of rocks, or under the shade of large trees. It may also ensue from the depredation of insects, nestling in the radicle, and consuming the nutriment of the plant, and thus debilitating the vessels of the leaf, so as to render them insusceptible to the action of light ; or it may arise from poverty of soil.

EXCITABILITY.—One of the most distinguishable properties of living vegetable structures is that of their excitability, or capacity of being acted upon by the application of natural *stimuli* impelling them to the exertion of their vegetative powers ;—the natural *stimuli* thus impelling them being light and heat.

I. The stimulating influence of light upon the living vegetable structure is discoverable, whether in the direction of the stem and branches, the position of the leaf, or the expansion of the flower.

If a plant is placed in a dark room or cave in which there is only one small aperture for the admission of light, the stem will gradually bend towards that aperture. Bonnet sowed some French-beans in a dark cave with a view to ascertain the effect of the small portion of light that was transmitted to them through the entrance. The result was that the stems were deflected in the direction of the mouth of the cave. Also, if a potatoe is left, by accident, to vegetate in a close vault or cellar, where there is but little access to light or air, the stem will shoot out to a great length in the direction of the light ; but pale, and limber, and trailing on the floor. The direction and luxuriance of the branches depend also on the presence and action of light, as is particularly the case of hot-house plants, the branches of which are not so conspicuously directed, either to the flue in quest of heat, or to the door or open sash in quest of air, as to the sun in quest of light. Hence it is that the branches of plants are often more luxuriant on the south side than on the north side, or, at the least, on the side that is best exposed to light.

The position of the leaf is also strongly affected by the action of light, to which it uniformly turns its upper surface. This may be readily perceived in the case of trees trained to a wall, from which the upper side of the leaf is, by consequence, always turned ; being on a south wall turned to the south, and on a north wall turned to the north ; and you cannot succeed in training it otherwise. For if the upper surface of the leaf is forcibly turned towards the wall, and confined in that position for a length of time, it will soon resume its original position upon regaining its liberty, but particularly if the atmosphere is clear. Bonnet tried to retain a leaf in a reversed position by means of twisting the leaf stalk ; but it was always found to untwist itself again in the course of a short time, and to present its upper surface to the sun or light.

Yet all leaves are not equally susceptible to the action of the *stimulus* of light. The leaves of Mallows are said to exhibit but slight indications of this susceptibility; as also sword-shaped leaves, and the leaves of the Mistletoe, which have never been known to resume a former position, in consequence of any change in the position of the branch on which it grows, because, perhaps, they are equally susceptible on both sides. But succulent leaves are said to be particularly susceptible, notwithstanding their thick and firm texture; and a leaf of the vine, if it is even separated from the branch, and suspended by a fine thread, with the upper surface turned from the light, will yet gradually alter its position till it comes round to the light again.

The expansion of the flower is also affected by the action of light. Many plants do not fully expand their petals except when the sun shines, and hence they alternately open them during the day, or at certain hours of the day, and shut them during the night. This is the *Horologium Floræ* of Linnæus, which you may find exemplified in the case of the Papilionaceæ, and of many of the Compositæ. But the most singular case of the kind is perhaps that of the *Lotus* of the Euphrates, as described by Theophrastus, which he represents [*Περὶ φυτῶν ἱστορ. το. Δ.*], as rearing and expanding its blossom by day, closing and sinking down beneath the surface of the water by night, so as to be beyond the reach of the hand, and again rising up in the morning to present its lovely and expanded blossom to the sun. [See *HOROLOGIUM FLORÆ*.]

Such are the effects produced upon stems, leaves, and flowers. Is light the sole agent? It had been conjectured that the effect is partly attributable to the agency of heat; and to try the value of the conjecture, Bonnet placed some plants of *Atriplex* in a stove heated to 25° of Reaumur. Yet the stems were not inclined to the side from which the greatest degree of heat came, but to a small opening in the stove. Heat then does not seem to exert any perceptible influence in the production of the above effects. Does moisture? Bonnet found that the leaves of the vine exhibited the same phenomena when left in water, as when left in the open air. Hence it seems evident that light is at least the chief agent in the production of the effects in question.

II. Heat, as well as light, acts also as a powerful *stimulus* to the exertion of the vital energies of the plant; as may be seen by watching the phenomena of germination, which does not succeed except at a certain temperature, as well as in the leafing and flowering of plants, together with that of the ripening of fruits, which form the foundation of what Linnæus has called the *Calendarium Floræ*,—which see.

But there are several other ways in which the agency of heat may

be observed as exciting to action the vital energies of the plant. The leaflets of some of the leguminous plants, when exposed to the action of an ardent sun, are often erected into a vertical position on each side of the leaf stalk, which they sometimes even pass so as to close together. Under similar circumstances the leaves of the Indian Mal-low become concave; a phenomenon evidently the result of heat, because the same effect may be produced even by means of the application of a hot iron. Several species of *Mimosa* exhibit a singular phenomenon even in the common foot-stalk, which is found to have a sort of natural movement dependent upon temperature also, so that it is elevated in the course of the day, and depressed in the course of the night, according to the observations of Duhamel. At nine o'clock in the morning of a day in the month of September, the weather being moderately fine, the foot-stalk of a leaf of *Mimosa pudica* formed by its position an angle of 100° with the lower part of the stem; at noon it formed an angle of 112° ; at three o'clock in the afternoon it had fallen to an angle of 100° ; and during the night it fell to an angle of 90° ; thus evidently rising and falling to the temperature of the surrounding atmosphere. This phenomenon, Duhamel was content to ascribe merely to the agency of heat, without making any further enquiries. But Dutrochet, who has studied the subject with great care, goes much further. According to him, the seat of the moving power is the tumour which is found at the base of the foot-stalk, and which he regards as composed of nervous globules, causing flexion and recovery from flexion, not by a joint, but merely by a bending of the organic tissue dependent on the three following conditions,—a temperature above 7° of Reaumur, insolation, abundance of sap. We do not at present enquire into the validity of this hypothesis. It will come with more propriety under the head of the article NERVI-MOTILITY.

As the elevation of temperature induced by the heat of summer is essential to the full exertion of the vital energies of the plant, so the depression of temperature consequent upon the colds in winter has been thought to suspend the exertion of the vital energies altogether. But this opinion is evidently founded upon a mistake, as is proved by the example of such plants as protrude their leaves or flowers chiefly in the winter season, such as *Daphne Mezereon*, and many of the Mosses; as well as by the dissection of the yet unfolded buds at different periods of the winter, showing a regular, and gradual, and incipient developement of parts, from the time of the bud's first appearance till its ultimate opening in the spring. Hence it follows that even during the period of winter, when vegetation seems wholly at a stand,—the tree being stripped of its foliage, and the herb apparently

withering in the frozen blast,—still the energies of vegetable life are exerted, and still they produce their due effects, carrying on in the interior of the plant, concealed from human view, and sheltered from the piercing frosts, operations necessary to the preservation of the individual, or protrusion of future parts; though it requires the returning warmth of spring to give that degree of velocity to the juices which shall render their motion cognizable to man, as well as that expression to the whole plant which is the most evident token of life; in the same manner as the processes of respiration, digestion, and the circulation of the blood, are carried on in the animal subject, even while asleep; though the most obvious indications of animal life are those of the movements of the animal when awake.

EXCENTRIC.—The embryo is said to be excentric when it is enclosed within the albumen, but not in the centre of it, as in *Asparagus*. [See DISSECTION OF SEEDS.]

EXOGENOUS.—Plants whose growth is effected by increments added to the circumference, are said to be exogenous. They are all dicotyledonous. But what are we to say of the growth of the primary shoot of the dicotyledonous seedling, or of the annual shoot of the fully developed plant? and to what previous circumference does it add a new layer? This subject requires to be further investigated.

EXTERNAL STRUCTURE.—The external structure of vegetables is that part of their fabric which is discoverable by outward inspection, as the root, stem, bud, branch, flower, and fruit; all which organs will form the ground of articles in their proper places.

EXOSMOSE.—A term introduced by M. Dutrochet, signifying a rush outwards, as applicable to the weaker impulse by which, through means of a current counter to that of endosmose, and simultaneous with it, a more dense fluid passes through animal or vegetable membrane to a less dense fluid, and hence applicable to certain peculiar movements occurring in the vegetable economy.

EXTRACT.—When vegetable substances are macerated in water, a considerable portion of them is dissolved; and if the water is again evaporated, the substance held in solution may be obtained in a separate state. This substance is denominated *extract*, though it must differ much in different plants. Vauquelin tried to reduce it to a single principle—the extractive; but as it was after all believed to be merely a mixture of various vegetable ingredients, it has ceased to be a leading object of chemical investigation.

FACE.—“That side of a seed which is most nearly parallel with the axis of a compound fruit, or the ventral suture, or sutural line of a simple fruit, is called the *face*, and the opposite side the back.”

Where the *raphé* is visible it indicates the face. [Lind. Introd. 181.]

FAIRY RINGS.—In passing over heaths or other pastures, the herb-orizer often meets with circular belts of herbage of a deeper shade of green than that of the general surface, encompassing a space of perhaps several yards in diameter. In the autumn, these belts are covered with *Fungi Mushrooms*. What is the cause of this phenomenon?

In former times it was reckoned very good philosophy to ascribe it to the traces left by the elves or fairies in their midnight revels, in which they were supposed to foot it on the “dewy green.” But after the time came when no man could see “no elves mo,” it became necessary to look out for a new explanation of the phenomenon.

Darwin ascribed it to discharges of electric matter bursting from the clouds, which he supposed to descend in a sort of circular form, calcining the herbage at the circumference, and thus forming a richer soil, and a richer herbage, or a fit bed for *Fungi*.

Withering ascribed it merely to the growth of *Fungi*. At first a tuft of fungi sprung up accidentally on some particular spot; but after a year the same soil suits it no longer. Hence it recedes from the centre to the circumference in quest of fresh soil, and now appears as a circular belt round a central space. When this belt is also exhausted, it recedes still farther from the centre, and leaves a green belt behind it, enriched by the decay of the fungi that grow on it.

Such are the two most popular hypotheses on this subject, of which Withering’s seems to be the nearest to the truth; though he does not well account for the appetency to circular growth which the *Fungi* effect, regarding it as peculiar to a few species only. But Messrs. Dutrochet and Turpin appear to have discovered, in the course of their investigations, the true and efficient cause of the phenomenon in question, and have thus been enabled to open up to us a correct and interesting view of the growth of the *Fungi*. [Annal. du Mus., Tome III., Livraisi.]

A sporule or seminule of an *Agaric*, for example, is conveyed through the ordinary means of dispersion, till it reaches a *nidus* fit for the evolution of its parts—say, some point on the surface whether of a meadow or of a heathy pasture. There it soon fixes itself, and begins to send out, immediately below the surface of the soil, small threads or branches in the direction of horizontal rays. These, as they extend, join by *anastomosis*, and branch off and join again, till they form a sort of net-work of fibres resembling the skeleton of a leaf. This, in *Agricus campestris* is the spawn which Gardeners deposit in Mushroom-beds as the rudiments of their future crop; which plexus M. Turpin designates by the name of *Thallus*; the mushroom itself

being merely the fruit. Now this fruit, which is produced towards the circumference of the rays, comes of course in the form of a circle, which, for the first year, is very small; and when it decays and dies, the central part of the *thallus* decays and dies along with it, giving, by their joint decomposition, a temporary fertility to the soil, with a deeper tinge of green to the grass that grows on it. Hence the first circular superficies of green. But while the *thallus* thus dies by the centre, it still lives and elongates by the circumference, carrying the fruit further from the centre every succeeding year, and thus enlarging the circle. Where the fertility is exhausted, which was communicated to the soil, in the first year of the plant's growth, the centre resumes its original and paler hue, and the shade of deep green is confined to the circumference, where it assumes the form of a circular belt, as it is usually to be met with in our green fields or meadows. If the soil is uniform, the circle is entire; if not, it is broken, or has never been formed, and the mushrooms are found solitary or in small patches.

Such is the origin and formation of Fairy Rings, according to Messrs. Dutrochet and Turpin, sanctioned by indubitable facts. We inquire not here whether the thallus or spawn is a *bissus* or not. We merely state the evidence that illustrates and ascertains the cause of circular growth. Withering says you meet with only one species of mushroom in one ring, and this we believe to be the fact.

FAMILY.—A family is an assemblage of allied genera, whose structure and disposition of parts are founded on the same symmetrical plan, and whose external part or habit indicates their affinity; the Mushroom, the Mosses, the Grasses, the Palms.

FASCICLE.—The fascicle is a species of inflorescence similar to that of the corymb, but having its peduncles more crowded and condensed, so as to form a sort of compact bundle. It is exemplified in *Dianthus*.

FECULA.—A term synonymous with Starch, which see.

FECUNDATION.—Admitting that the stamens and pistils are the male and female organs of vegetable generation, and that the pollen is the substance by which the fecundation of the seed is effected, how, after all, is it conveyed to the pistil or to the ovary, and what is the amount of its action?

When the stamens and pistils are situated near each other, as in the case whether of Hermaphrodite or Monæcious flowers, the elastic spring with which the anther flies open, will generally be sufficient to disperse the pollen so as that part of it must infallibly reach the stigma. There are also additional facilities tending to ensure the access of the pollen, in the relative position, situation, and mutual sympathies of the stamens and pistils, as well as in the possible action of winds wafting the pollen to a distance, and hence including the case

of Diæcious flowers also. But with all the above facilities the impregnation of the ovulum would still in many cases be impracticable, even in Hermaphrodite flowers, without further aid; particularly in such as do not perfect their stamens and pistils at the same time, or where the very figure of the corolla, or structure of the flower, may operate as a bar to the entrance of the pollen.

What then are the means instituted by nature for the fecundation of Hermaphrodites so circumstanced? The true reply to this inquiry seems to have been first suggested by Koëltreuter,—namely, the agency of insects; and it has been since confirmed by the more leisurely observations of Sprengel, who found that the pollen in the above case is very generally conveyed from the anther to the stigma, through the instrumentality of Bees. The object of the insect is the discovery of honey, in quest of which, whilst it roves from flower to flower, and rummages the recesses of the corolla, it unintentionally covers its body with pollen, which it conveys to the next flower that it visits, and brushes it off as it acquired it, by rummaging for honey; so that part of it is thus almost unavoidably deposited on the stigma, and fecundation thus effected. Nor is this altogether so much a work of random as it at first appears; for it has been observed that even insects, which do not upon the whole confine themselves to one species of flower, will yet very often remain during the whole day upon the species they first happen to alight on in the morning. Their agency is also completely secured from the necessity they are under of procuring food; while Nature, in her care for the fecundation of the seed, has not only lodged a honey in the flower to tempt the taste of insects, but seems to have furnished also the means of tempting even the eye; the coloured spots with which many flowers secreting a honied fluid are marked, being regarded as indicating the contained treasure. They are the *maculæ indicantes* of Sprengel, who has enumerated several hundreds of flowers, which in their figure or colour resemble insects, and hence attract the plunderers of their honied stores. The beautiful example of the Bee Orchis is known to almost every body.

Monæcious plants are, according to Sprengel, mostly fecundated by insects also. But many of them do not require that aid, particularly if the male and female flowers stand close together, as in Typha, Coix, Carex. The same thing may be said of many Diæcious plants, as well as of the Fig—Polygamia Triœcia, which is accomplished by Caprifigation.

From the fact of the agency of insects in the conveying of the pollen to the stigma, it will follow that no plant requiring such aid can possibly perfect its seed unless the specific insect has access to it, or unless some such aid is given to it by the cultivator. Hence,

botanists attribute the imperfection of the seeds of hot-house plants, to the want of the insect by which the species may be fecundated in its native climate; and gardeners often do its work for it.

By the means above stated, the pollen is conveyed to the stigma, but how is it conducted thence to the ovary, and ultimately to the ovulum itself? It was at one time generally supposed that the pollen is conducted from the stigma to the ovary by means of a longitudinal canal perforating the style. This canal is distinguishable in many of the liliaceous plants, and seems indeed capable of giving passage to the pollen, particularly as it occurs in *Amaryllis formosissima*, in which the fluid exuding from the stigma is again absorbed with particles of pollen intermixed. But the existence of the canal in question, though distinguishable in *Amaryllis formosissima*, and other liliaceous plants, cannot be admitted as a universal property of the style; or at the least it cannot be detected; and if it is so very fine as to escape all detection, how could it admit the particles of pollen, which in some plants, as Marvel of Peru, exceed in diameter even the style itself?

After all, it does not seem to be necessary that the particles of pollen should enter the style entire. The finer part of their contents might be sufficient. This was the opinion of Grew and Adanson, who regarded the fecundating principle to be a subtle and elastic vapour; or an oily and gelatinous fluid, exuding or exploding from the globule, and capable of being conducted to the ovary, through the channel of the cells or vessels of the style, without the aid of a central canal.

But it is to the investigations of phytologists of a more modern school that we are indebted for the discovery of the true means employed by nature to conduct the fecundating principle of the pollen through the substance of the stigma and style till it reaches the incipient ovulum. Amici seems to have been the first to catch a glimpse of this mysterious process in 1823 [Osserv. Micros. fig. 16], and his observations have been since confirmed both by M. Adolphe Brongniart, and by Dr. R. Brown. When the globules of pollen are discharged from the anther, and carried, whether by their own gravity, or by the agitations of the atmosphere, or by the agency of insects, to the summit of the pistil, from which there now exudes a viscous fluid, they are thus moistened and detained on its surface, and are found after a certain period to protrude boyaux or pollen tubes, by a prolongation of their inner integument, which, penetrating and pervading the stigma and style, reach at last the ovulum, and enter it by the micropyle. It is at this period that the merry movements of the contained molecules of pollen are to be seen, as they occur in the natural processes of fecundation,—mixing, and mingling, and frolicking as

they pass on, and ultimately communicating to the ovula, the attributer of fertility. We refer the reader for an account of almost every thing worth knowing on the subject to Dr. Brown's paper "On the Mode of Fecundation in Orchideæ and Asclepiadeæ," to be found in vol. xvi. of the "Linnæan Transactions," and to his publication on *Active Molecules*.

A question has been raised with regard to the quantity of pollen necessary to the fecundation of the ovula of any given flower. Adanson was of opinion that the smallest possible particle was sufficient; but the experiments of Koëltreuter show that his opinion was founded in error. The globules of pollen contained in all the anthers of an individual flower of *Hibiscus Syriacus* were 4863, of which 50 at least were necessary to a complete fecundation; for when fewer globules were applied the seeds were not all ripened, and ten globules were the least by which the fecundation of even a single seed could be effected in this plant. [Wild. Princip. Engl. Trans. 323.] This account tallies better with the observations of the discoverers of the boyaux, or pollen tubes, one of which is represented as going to each ovulum.

Still there remains a question with regard to the specific agency of the pollen, after it has found its way to the ovulum. This has given rise to the three following theories: the theory of the ovarist,—the theory of the animalculist,—and the theory of the epigenisist.

The ovarist regards the embryo or germ of the future seed as pre-existing in the ovulum from the first, where it awaits the fecundating influence of the pollen to arouse its vital energies, and to endow it with a distinct vegetable life. It is thus the analogue of the animal ovum. This seems to have been the opinion of Grew, who says expressly, that when the summits of the stamens open, and the pollen is discharged from the pistil, some subtle and vivifying effluvium escapes, which, descending through the medium of the style, impregnates the embryo. Bonnet and Haller seem to have been of the same opinion also, as well as many other eminent naturalists. But the most convincing evidence in support of the opinion of the ovarist, is that which has been produced by Spallanzani, as founded on a series of observations on the flowers of *Spartium junceum*, and a variety of other plants, from which he concludes that the seeds pre-exist in the ovary before the access of the pollen, by which they are merely rendered fertile; and contends that the embryo, though not previously perceptible, may yet previously exist. [Spall. Disser. 2141. Eng. Trans.] This theory derives support from the analogy of the process for which the ovarist contends, to that of the generation of the animal egg, which is represented by many anatomists as being formed complete in all its

integral and individual parts without the co-operation of the male, which adds to it merely the principle of fertility. Finally, it is further countenanced from the fact of the apparent and numerical perfection of parts often observable in the fruit of insulated female plants, in which, as I believe, the embryo is not always and altogether wanting, but only not fecundated.

Though the theory of the ovarist is countenanced by the above authorities, yet it is not without its difficulties. For as the embryo is but rarely, or rather perhaps never found to make its appearance till after fecundation, it has been thought that it must necessarily pre-exist in the pollen of the anther, whence it is conveyed to the ovary through the medium of the style, and afterwards matured. This theory was founded upon that of Leuenhoeck with regard to animal fecundation, which supposes the pre-existence of animalcula in the seminal principle of the male; the animalcula being conveyed *in coitu* to the uterus of the female, where alone they are capable of development. Hence it was denominated the theory of the animalculists, and transferred to the case of vegetables, by Morland, Needham, Gleichen, and others, who regarded the pollen as being a congeries of seminal plants, one of which, at least, must be conveyed to the ovulum entire before it can become prolific.

But if the embryo is to pre-exist at all, is it not more likely that it should pre-exist in the ovulum where it is to be brought to maturity, than that it should first be generated in one organ or plant, and then transferred to another to be developed there? Further, if the embryo pre-exists in the ovary, ought it not to be visible by inspection? Spallanzani could find no trace of an embryo in any pollen whatever. But the animalculist has a right to say in reply, what Spallanzani said with regard to its invisibility in the ovary before fecundation—Though it is not visible it may yet exist. Hence no conclusion can be drawn on either side from the circumstance of its invisibility.

The difficulties inseparable from both of the foregoing theories, together with the phenomenon of hybrid productions, have given rise to a third theory. This is the theory of the Epigenisist, who maintains that the embryo pre-exists neither in the ovary nor pollen, but is generated by the union of the fecundating principles of the male and female organs; the former being the fluid issuing from the pollen when it explodes; and the latter, the fluid that exudes from the surface of the stigma when mature. As applicable to the vegetable kingdom, this theory has been stoutly defended by Koëlreuter, who adduces in support of it many experiments, of which the following may be regarded as giving the most favourable result. A flower of *Nicotiana rustica* was deprived of all its stamens, and fecundated

with pollen from a flower of *Nicotiana paniculata*. The plant raised from the seed thus obtained was a hybrid, exhibiting in all its parts an intermediate character betwixt the two species from which it sprang. The stamens of this hybrid, as well as of all others he ever raised, were imperfect; but when its pistils were impregnated with pollen from the *paniculata* as before, the new hybrid obtained from the seeds now produced was more like a *paniculata* than formerly; and when the experiment was continued through several successive generations, the plant was at last converted into a perfect *paniculata*. [Wild. Eng. Trans. 328.]

This is thought to be an infallible demonstration of the truth of the doctrine of the epigenisist. But we think there is still left enough of room for doubt. For why may not the pollen of one species of plant be allowed to produce some particular change upon the development of the embryo of another species of plant, although that embryo should be supposed to have pre-existed in the ovary? The action of the pollen thus introduced must amount to something, and it is just as difficult to conceive how an individual, whether proper or hybrid, should be generated from two seminal principles of the same or of a different species, as it is to conceive how the agency of the pollen of the same or of a different species should confer fertility and individual life upon an embryo already pre-existing. Hence the three theories decide nothing. [See the article POLLEN.]

FELLING.—Felling is the operation of cutting down trees close to the ground, which many of them will yet survive, if the stump is protected from the injuries of animals, and the root fresh and vigorous. In this case the fibres of the wood are never again regenerated, but a lip is formed as in the case of pruning, and buds that spring up into new shoots are protruded near the section; so that from the old stock, ten, twelve, or even twenty new shoots may issue according to its size and vigour. The stools of the Oak and Ash-tree will furnish good examples; but there are some trees, such as the Fir, that never send out any shoots after the operation of felling.

FENCE.—The fence is the calyx or involucre of mosses—*perichætium*—being an assemblage of loosely imbricated scales terminating in a fine hair or bristle, and surrounding the female flower. It is particularly conspicuous in the genus Hypnum.

FERNS.—Ferns are herbaceous, and, for the most part, stemless plants, dying down to the ground in the winter, but furnished with a perennial root, whence there issues, annually, a frond bearing the fructification, which, being obscure or cryptogamous in its character, places them necessarily in the class of plants called Imperfect. The

favourite stations of many of them are heaths and uncultivated grounds, intermixed with furze and brambles.

“Neglectis urenda *felix* innascitur agris.”—HOR. Lib. I. Sat. iii. 37.

Some of them will thrive even on the dry and barren rock, or in the chinks and fissures of walls: but the stations of such as are the most luxuriant in their growth are moist and fertile spots in shady and retired situations, as on mossy dripping rocks, or by fountains and rills of water.

The root of the tribe of ferns assumes a great variety of different aspects in different species. In *Botrychium Lunaria* it is fibrous; in *Aspidium dilatatum* it is tuberous; and in *Polypodium vulgare* it is creeping and covered with scales. In *Pteris aquilina*, or Common Brakes, it is sometimes described as being spindle-shaped: yet this is not strictly the fact. If a frond is taken and pulled up with the hand, the lower portion of it is indeed spindle-shaped; but the real root, or rather rhizoma, or root-stock, from which you have thus detached the frond, remains still in the soil, elongating in a horizontal direction at the depth of from three to four inches, sometimes simple and sometimes branched, but always furnished with lateral fibres.

The trunk of Ferns—if trunk “it can be called which trunk is none”—is a stipe supporting the frond; or rather the whole of the herbage is a frond—that is, an incorporation of stipe, leaf, and fructification. Yet in *Equisetum* the trunk is a jointed and upright stem; in *Pilularia* it is jointed and trailing; in *Lycopodium* it is lash-shaped and creeping. If the stipe of a Dorsiferous Fern is cut open, it will be found to consist of a firm pulp or pith, interspersed with bundles of longitudinal fibres of a dusky brown colour, assuming an arrangement proper to the species. On a transverse section of the stipe of *Pteris aquilina*, taken a little above the surface of the soil, the divided extremities of the bundles exhibit a slight resemblance to an oak-tree in full leaf. This has been noticed even by the peasantry of the country, among whom it is known by the name of King Charles’s Oak. But if the section is taken in a slanting direction, then the resemblance exhibited is that of the Eagle of the Roman standard; whence, as I believe, we have the trivial name.

Ferns, strictly so called, have neither distinct branches nor distinct leaves. Yet in the Lycopodiaceæ Equisetaceæ leaves and branches are both to be found. But these divisions of the tribe of ferns, as well as also the Marsiliaceæ, have so much in their structure that is peculiar to themselves, that botanists begin to look upon them as forming distinct tribes.

It was for a long time believed that ferns are destitute of seeds,

and propagated nobody knows how. Yet no botanist of the present day doubts the reality of fern-seed, or at the least of sporules from which new plants spring. Some have even fancied that they had detected the parts of the antecedent flower. [Hedwig Theor. Fruct.] But admitting that such detection is impracticable, the botanist can, at least, direct his attention to the mode of fructification, and to the fruit produced. In *Lycopodium* the fruit is axillary; in *Equisetum* it is terminal; and in *Isöetes* and *Pilularia* it may be said to be radical. In ferns, strictly so called, it is dorsal,—that is, scattered in clusters or patches on the back of the frond. These patches are generally accompanied with an integument called the *Indusium*, which, at the period of the maturity of the seed, bursts open, sometimes towards the nerves and sometimes towards the margin, but in plants of a similar habit, uniformly in a similar manner. The merit of this discovery is due exclusively to Sir J. E. Smith, who found it to be a most decisive criterion for the determining of natural genera, and the only sure ground on which the botanist can rely. [Smith's Tracts, 227.] When this integument bursts, the fruit, now ripe, escapes, which is for the most part a capsule surrounded by an elastic and jointed ring opening transversely, and discharging the enclosed seed or sporule, which is a small and minute globule, discoverable only by the microscope, and capable of giving origin to a new plant. Ferns were raised from the sowing of their seeds in 1789 by Mr. J. Lindsay, of Jamaica, as also by Mr. J. Fox, of Norwich, about the same time. [Lin. Trans. vol. ii.]

FERTILE FLOWERS.—Flowers containing pistils only are said to be fertile, because they produce seeds, in contradistinction to flowers containing stamens only, which are said to be barren, because they produce no seeds.

FERTILITY OF VEGETABLES.—The fertility of plants or of flowers is extremely different in different species. In some plants a single flower produces only a single seed, as in *Statice* or *Thrift*; in some it produces two seeds, as in the *Umbelliferæ*; in some it produces three, as in *Euphorbiaceæ*; in some four, as in the *Labiataæ*; and in some many, as in *Ranunculaceæ*. But the great fertility of some particular species is altogether astonishing. A single capsule of tobacco often contains one thousand seeds; a single capsule of *Papaver somniferum* has been known to contain eight thousand seeds; and a single capsule of *Vanilla aromatica* has been known to contain from ten thousand to fifteen thousand seeds. Further, a single plant of tobacco has been found by calculation to produce the almost incredible number of three hundred and sixty thousand seeds; and a single stalk of spleenwort has been thought by estimation to produce at least a million of seeds.

FIBRINE.—From the blood and muscles of animals chemists extract a peculiar substance, which they denominate fibrine or fibrina. It constitutes the fibrous part of the muscles, and resembles gluten in its appearance and elasticity. It is insoluble in water and in alcohol, but soluble in acids. With nitric acid it yields much of azote, and by distillation it yields carbonate of ammonia and oil. Its taste is insipid; but the inspissated juice of the Papaw-tree was found by Vauquelin to possess the same properties. It is insoluble in water, though not wholly so. It is soluble in acids, and with nitric acid disengages much azote. When thrown upon ignited charcoal it melts, exuding drops of grease, and exhaling an animal odour. It has been since detected by M. M. Bussingault and Rivero in the milky juice of *Galacto—dendron utile*; the *Palo de vaca*, or Cow-tree of South America. [Dec. Phys. Veg. i. 262.]

FILAMENT.—The filament is that portion of the stamen which supports the anther, and attaches it to the receptacle. Yet it is not always thread-shaped, as the name might lead us to suppose. In some species it is awl-shaped, in others it is club-shaped, and in others, as in *Nymphæa*, it is petaloid, that is, expanding like a petal.—Nor is it universally present, as forming essentially a part of the flower; for some anthers are sessile, and consequently without filaments. The filaments are usually distinct, but they are sometimes united into one or more sets, and are hence said to be monadelphous, diadelphous, or polyadelphous.

FLATTENED STEM.—It sometimes happens that a stem, instead of assuming the cylindrical form common to the species, assumes a compressed and flattened form, similar to the herbage of a *Cactus*. This is the flattened stem. It is apt to occur in the stem of *Tamus communis*, which, instead of being elongated in the shape of a cylinder, is converted into a flattened and oblong shape of about an inch in breadth. The stem or branches of the ash-tree are also subject to this anomaly. The stem of an ash-tree thus flattened terminated in a strap of about two inches in breadth, surmounted by a row of buds of between twenty and thirty in number. [Keith's Phys. Bot. 11. 275.] Duhamel accounted for the anomaly by supposing an unnatural graft and union of shoots to have taken place in the leaf-bud. But if shoots should be thus united, why should they be flattened in their aggregate growth?

FLORAL LEAVES.—A floral leaf is only another name for the *Bracte*,—which see.

FLORETS.—The individual flowers of which a compound or aggregate flower is composed are denominated florets or floscules. In the Compositæ they are ligulate or tubular. The latter are the florets of the disk; the former, of the ray.

FLOWER.—The flower, which, like the leaf, belongs to the division of the temporary parts of the plant, is a production that issues generally from the extremity of the branches, but sometimes also from the root, stem, and even leaf, being the apparatus destined by nature for the generation of the future fruit, and being distinguished, for the most part, by the brilliancy of its colouring, or sweetness of its smell. It has been happily styled by Pliny—the joy of plants—*Flos gaudium arborum*; of which the Lily, the Tulip, and the lovely Rose, so sweetly sung by Anacreon of old, are magnificent examples.

“Ρόδον ὦ φέριστον ἄνθος,
 ‘Ρόδον ἔαρος μέλημα,
 ‘Ρόδα καὶ θεοῖσι τερπνά.”—Ode V.

“O Rose the most excellent of flowers!
 The rose the delight of the spring;—
 Roses are delightful even to the Gods.”

Among the most splendid of all known flowers is that of the Laurel Magnolia of East Florida, which, when fully expanded, gives a width across measuring not less than from six to nine inches. [Bartram's Travels.] A much larger flower, however, is that of *Aristolochia cordifolia*, which is said to give a breadth across of at least sixteen inches. This seems enormous; and yet it is nothing in comparison of the extraordinary and gigantic dimensions of the fully expanded flower of *Rafflexia Arnoldi*, which displays a diameter, as ascertained by actual measurement, of not less than three feet. [Lin. Trans. vol. xiii., Pt. I.]

Flowers in their mode of attachment are either sessile, as in agrimony, or supported upon a peduncle, as in Primula. In their direction they are upright or bending, or nodding or unilateral—that is, attached to one side of the stem only, as in Lily of the Valley. If they issue from the root, they are radical; if from the stem, they are circular; if from the branch, rameal; if from the leaf, foliary, as in *Ruscus*: but in all their varieties they are generally divisible into the following distinct parts,—the calyx, the corolla, the stamens, the pistil, which will be found in their proper places.

FLUX OF JUICES.—When the sap ascends more copiously than it can be carried off, it often occasions a fissure of the solid parts, inducing disease or deformity, by encouraging the extravasation and corruption of the contained fluids, or a morbid flux of juices. The fissure is sometimes occasioned by frost, forming what is called a double alburnum; that is, first, a layer that has been injured by the frost, and then a layer that passes into wood. But a cleft thus oc-

casioned often degenerates into a chilblain that discharges a blackish and acrid fluid, to the great detriment of the plant, particularly if it is so situated that rain or snow will readily lodge in it. The sooner a remedy is applied to it the better, for it will not heal of itself; and the only remedy yet known is the excision of the part affected, and the application of a coat of grafting wax. [Willdenow, 353, Eng. Trans.]

FOLIATION.—The peculiar mode in which the incipient leaves are folded up within the leaf-bud is designated by the term foliation or vernation. Linnæus enumerated ten varieties of mode, which are introduced and explained at the article **BUD**.

FOLIOLES.—Folioles, a diminutive from folium, a leaf, is a term sometimes used to denote the leaflets of winged or compound leaves. They are opposite or alternate, ending abruptly or with an odd leaflet.

FOOD OF THE VEGETATING PLANT.—If the embryo, when converted into a plant and fixed in the soil, is now capable of abstracting from the earth or atmosphere the nutriment necessary to its growth and developement, the next object of the phytologist's inquiry will be that of ascertaining the substances which it actually abstracts, or the food of the vegetating plant.

What then are the component principles of the soil and atmosphere? The investigations and discoveries of modern chemists have done much to elucidate this dark and intricate subject. Soil, in general, may be regarded as consisting of earths, water, vegetable mould, decayed animal substances, salts, ores, alkalies, gases, perhaps in a proportion corresponding to the order in which they are now enumerated; which is at any rate the fact with regard to the three first, though their relative proportions are by no means uniform. The atmosphere has been also found to consist of at least four species of elastic matter, —nitrogen, oxygen, carbonic acid gas, and vapour; together with a multitude of minute particles detached from the solid bodies occupying the surface of the earth, and wafted upon the winds. Of the three gases that constitute the bulk of the atmosphere, nitrogen may be regarded as occupying about 78 parts in the hundred, oxygen about 21 or 22 parts, and carbonic acid gas about 1 part.

But all of the ingredients of the soil and atmosphere are not taken up indiscriminately by the plant and converted into vegetable food; because all plants do not thrive indiscriminately in all soils. Part only of the ingredients are selected, and in certain proportions, as is evident from the result of chemical analysis, by which it has been shown that vegetable substances are reducible chiefly to carbon, oxygen, and hydrogen; while nitrogen, and the other ingredients that have been discovered in plants, occur but in small proportions. Yet it does not follow that the selected ingredients enter the plant always in

an uncombined or insulated state; it follows only that they are inhaled or absorbed by the plant under one modification or another. Neither does it follow that they are selected according to the proportions in which they exist in the soil or atmosphere, but according to the necessities of the plant. What then are the substances actually selected; in what state are they taken up; and in what proportions? We may reduce them to the three following heads; water, gases simple or combined, and substances soluble in water.

I. As water is necessary to the germination of the seed, so also is it necessary to the growth of the plant. Plants will not continue to vegetate unless their roots are supplied with water; and if they are kept long without it they will droop and languish. Yet many plants will grow and thrive, and effect the developement of their parts, if the root is merely immersed in water, though not fixed in the soil. Lilies, hyacinths, and a variety of plants with bulbous roots, may be so reared, and are often to be met with so vegetating, and many plants will vegetate though wholly immersed. Most of the marine plants are of this description. It can scarcely be doubted, therefore, that water serves the purpose of a vegetable aliment.

But if plants cannot be made to vegetate without water, and if they will vegetate, some when partly immersed without the assistance of soil, and some even when totally immersed, so as that no other food seems to have access to them, does it not follow that water is the sole food of plants, the soil being merely the basis on which they rest, and the receptacle of their food? This opinion has had many advocates, and the arguments and experiments adduced in support of it were, at one time, thought to have completely established its truth. It was, indeed, the prevailing opinion of the seventeenth century, and was embraced by several philosophers even of the eighteenth century; but its ablest and most zealous advocates were Van Helmont, Boyle, Duhamel, and Bonnet, who contended that water, by virtue of the vital energy of the plant, was sufficient to form all the different substances contained in vegetables.

The most famous experiment adduced in support of this opinion was that of Van Helmont. This philosopher planted a willow weighing 50lbs. in an earthen vessel containing a known quantity of earth, which had been previously dried in an oven. He moistened it with distilled water, or with rain water, and took care to prevent any accession of other earth. At the end of five years the plant was taken up and weighed. Its weight, together with that of all its leaves, was 169½lbs., and the weight of the earth only two ounces less than at first, giving an accession in weight of 119½lbs., which was to be accounted for, as it was thought, only from the water with which the

earth was moistened. Hence it was concluded that water is the sole food of plants ; the two ounces of earth lost being regarded as bearing too small a proportion to the increased weight of the willow to deserve any notice in the calculation.

But if earths are necessary to the health of the vegetating plant, there was nothing in the conditions of the experiment to prevent their access. Part of the earth contained in the flower-pot was no doubt soluble in water, and might have entered the plant thus ; and if not, still it might have entered it along with the rain water with which the plant was occasionally moistened ; as it has been found from the experiments of Margraff, that one pound of rain water contains one grain of earth, as well as shown by Hales and others that unglazed earthen vessels, when placed in the earth, will readily absorb moisture from the surrounding soil ; and if moisture, then, by consequence, whatever substances the moisture holds in solution. The access of earth then is accounted for, without the necessity of having recourse to the joint efforts of the water, and of the living energies of the plant. Yet the experiment was shown by Hassenfratz and by Saussure to be still more palpably defective on the score of its giving no account of the carbon contained in the plant. Did not the carbon of the plant increase also, as well as its other ingredients ?—and from what source did its increase come ? These questions remained untouched and unanswered ; and chemistry knows nothing of the convertibility of water into carbon.

II. When it was found that water is not the sole food of plants, recourse was next had to the assistance of the atmospheric air ; and it was believed that the vital energy of the plant is at least capable of furnishing all the different ingredients of the vegetable substance, by means of decomposing and combining in different ways atmospheric air and water. This was an approach to the fact, but still it involved something of fiction. For though the great utility of atmospheric air, and even its absolute necessity to the support of vegetable life, could not be denied, yet it was not to be admitted without proof that air, together with water, forms the whole of the vegetable aliment. It was not enough to say that some plants, such as the Mosses and Lichens, seem to effect the developement of their parts without the aid of any other nourishment beyond that of air, rains, and dews. These tribes form but a small portion of the vegetable kingdom, being slow of growth, and tenacious of life. But plants of rapid growth never effect that developement without the aid of nourishment derived from the soil. Saussure made the experiment upon beans, peas, and cresses, by placing them in horse-hair, or in pure sand, and moistening them with distilled water. They grew indeed, and some of them

even flowered, but never produced perfect seed. Hence the conclusion seems unavoidable, that atmospheric air and water are not the only principles constituting the food of plants. Neither are all the principles even of the atmospheric air equally available to the purposes of vegetation, or inhaled indiscriminately by the plant as a food. A selection is made of such principles only as are available to nutrition.

Carbonic acid gas is one of the gaseous principles of the atmosphere which vegetating plants select, being the grand principle of vegetable nutrition. For though, in the process of the germination of the seed, its application was found to be altogether prejudicial, yet in the process of subsequent vegetation its application has been found to be extremely beneficial. Plants, it is true, will not continue to vegetate in an atmosphere of pure carbonic acid [Priestley on Air, i. 36]; but neither will they continue to thrive in an atmosphere that is wholly deprived of it; yet Saussure has shown that if their atmosphere is charged with an additional dose of carbonic acid beyond that of the proportion in which it exists in common air, their vegetation becomes more vigorous and luxuriant, at least if exposed to the light of day, till the additional dose amounts to $\frac{1}{12}$ of the volume of their atmosphere. [Sur la Veg. chap. ii. sec. 5.] But the result was not the same when the plant was placed in the shade; for then the smallest additional dose was found to be prejudicial. Hence we may infer that plants vegetating in the sun inhale carbonic acid gas, as a food, by the leaves and branches. But they absorb it also as a food when applied to the roots. Plants, whose roots were moistened with acidulated water, soon surpassed in growth others whose roots were moistened merely with distilled water.

Oxygen is also one of the gaseous principles of the atmosphere which vegetating plants select. Branches of woody plants taken in the spring, immediately before the expansion of the bud, and enclosed in receivers filled with common air, together with a small quantity of water to supply them with moisture, were found by Saussure to develop their leaves as if attached to the parent plant. But this developement was effected solely by means of the oxygen contained in the receiver; for in mediums deprived of oxygen no developement took place. [Sur la Veg. chap. ii. sec. 8.] Similar experiments were made on the root, flower, and fruit, from all of which it follows that oxygen is indispensable to the developement of the vegetating plant.

As carbonic acid gas and oxygen, though constituting but a small proportion of the atmospheric air, are found to be highly available to vegetation, so nitrogen, it might be presumed, ought to be equally available, in proportion to its mass. This was in fact the opinion of Priestley, and of the earlier pneumatic chemists. Priestley found, as it

seems, that some sprigs of Mint on which he was experimenting vegetated better in what he called phlogisticated air, than in either dephlogisticated or common air; and hence he inferred that phlogisticated air,—the nitrogen of modern chemists, but, according to him, air charged with phlogiston, serves as a vegetable food. [On Air, vol. ii. 311.] In this opinion he was followed by Ingenhoutz, whose researches appear to have had a similar result. But Saussure, before the test of whose decisive experiments error was dispelled, as if by magic, has shown that as seeds will not germinate in nitrogen, so neither will plants vegetate in it. Branches of *Populus nigra*, whose leaf-buds were just ready to open, were introduced by Saussure into an atmosphere of nitrogen both in sun and shade. They effected no further developement of parts, but were found to be in a state of putrefaction after a period of five days; but in an atmosphere of common air they readily effected their developement, and continued to vegetate for many weeks. Some plants, as *Sedum telephium*, will continue to support vegetation in nitrogen gas for a limited time, and others, as *Lythrum Salicaria*, even for an indefinite time, and yet after all they do not inhale it. There was in no case any diminution of the original quantity of nitrogen introduced into the receiver. Hence it follows that nitrogen, at least in its pure state, is not a vegetable food. Yet a small quantity of it is found in almost all vegetables. Whence is it derived? Perhaps from the extractive principle of vegetable mould. [Sur la Veg. chap. vi. sec. 2.]

III. As other substances beyond those of water and atmospheric air seem necessary to healthy vegetation, so nature has taken care to place them within the reach of the plant. All substances lodged in the soil are capable of entering the plant if soluble in water. Some of them may possibly be prejudicial to the plant, and operate upon it as a poison, but others are undoubtedly wholesome.

Vegetable mould constitutes a considerable proportion of the soil, and is partly soluble in water. It is now a vegetable extract, capable of being absorbed by the root, and again converted into vegetable nourishment. Yet it is not necessary to the fertility of any soil that its extract should exist in a large proportion. Mould taken from a well-cultivated corn-field and macerated in distilled water yielded only four parts of extract in 10,000 parts of fluid. A mould containing $\frac{1}{4}$ of its weight of extract was less fertile than a mould that contained only $\frac{1}{2}$ or $\frac{2}{3}$ of that quantity; but mould deprived of all its extract [Sur. la Veg. chap. v. sec. 2], was rendered less fertile in an equal degree. Hence it follows that extract constitutes a vegetable food. But it contains a portion of nitrogen; and thus we may legitimately account for the introduction of nitrogen into the vegetating plant.

Most plants are found by analysis to contain a certain proportion of salts—as nitrate, muriate, and sulphate of potass or soda. How do plants acquire them? In the earlier periods of phytological investigation, when every thing was attributed to the agency of the vital principle as exerted upon the air or water which the plant inhales or absorbs, it was thought that the salts contained in vegetables are formed in the process of vegetation. But this is only one of those extravagant fictions which patient experiment has exploded. It is certain that the roots of plants may be made to take up a considerable proportion of salts in a state of artificial solution. Now the salts which have been detected in vegetables are known to exist in the soil. Hence there is reason to presume that they are taken up by the roots of plants vegetating even in their natural habitations.

But if salts are thus taken up, does it appear that they are taken up as a food? Some plants, it must be confessed, are injured by the application of salts, as is evident from the experiments of Saussure [*Sur la Veg.* chap. viii. sec. 2]; but others are as evidently benefited by it. Trefoil and lucerne have their growth much accelerated by the application of sulphate of lime. Parietaria, the Nettle, and Borage, will not thrive except in such soils as contain nitrate of lime, or of potass; and plants inhabiting the sea-coast, as was long ago observed by Duhamel, will not thrive in a soil that does not contain muriate of soda. It is to no purpose to say that the salts found in vegetables are merely accidental in their occurrence, and not necessary to the health or perfection of the individual, because they exist in but a small proportion, whether in the soil or plant. They exist in the soil in a greater proportion than is generally believed; and if even that is but little, plants require but little of them. What they take up, however, may be essential. Phosphate of lime constitutes but a very small proportion of the bones of animals, perhaps not so much as one part in five hundred, yet no one doubts that it is essential to their composition. Now the same salt is found in the ashes of all vegetables [*Saus. Sur la Veg.* chap. viii. sec. 4], and who will say that it is not essential to their perfection? or that salts are not to be regarded as a vegetable food?

As most plants have been found by analysis to contain a portion of alkaline or earthy salts, so most plants have been found to contain also a portion of earths. Whence are the earths derived? It was the opinion of Lampadius that the earths contained in plants are merely the effect of vegetation, and altogether independent of the soil in which they grow. But this conclusion, which had the semblance of resting upon copious and cautious experiment, has been since shown by Saussure to be most palpably erroneous. The experiment was as

follows :—Five beds, four feet square by one foot in depth, each containing a pure earth,—alumine, silica, lime, magnesia, garden mould, and each mixed with eight pounds of cow-dung, were sown with rye. The produce of each was separately reduced to ashes, and the same principles were found in them all, particularly a portion of silica. Whence came the silica in the bed of alumine? According to Lampadius it was the result of vegetation. But Saussure, after Ruckert, has shown that cow-dung contains a portion of silica. [Sur la Veg. chap. ix. sect. 3.] Hence the substance which Lampadius could not account for but by means of vegetation, he had supplied with his own hands. It is now known that the earths are partially soluble, some of them in pure water, and all of them, as I believe, with the aid of acids; so that we may fairly presume that they are taken up in solution by the root, and converted to the purposes of vegetation. Not that they are capable of affording any considerable degree of nourishment to the plant, but that some plants seem to be benefited by absorbing them. The grasses have their stems thus strengthened, and the Equisetaceæ and Palms have their stems or leaves better fitted for the purposes of art. The leaves of Palms make a substantial thatch for covering houses, owing to the silica they contain, and the Dutch Rush is made use of to polish even brass.

FORAMEN.—A term introduced by Grew to denote a perforation that is generally visible on the testa or outer coat of the seed. It is the micropyle of Mirbel, and is always to be found facing the radicle of the embryo.

FOSSIL BOTANY.—Geologists have discovered that the crust of the globe which we inhabit is composed of a variety of heterogeneous strata superincumbent upon one another, in a sort of regular series, and appearing to have been formed at different geological epochs. Not that they are always uninterruptedly concentric; they are, on the contrary, often interrupted in a variety of ways,—as by the upheaving of the primitive rocks, breaking the line of the continuity of the superior strata, and elevating their fractured extremities, which are often overlaid with new and horizontal strata; or by the occurrence of dykes or ridges crossing and dividing them in a transverse direction. Most of them have been found to contain organic remains, animal or vegetable, or both. In the lowest or primitive formations,—namely, the granitic,—there are indeed no traces of organized bodies to be met with. Hence it is inferred that the origin of the granitic rocks was anterior to that of organized beings. But in the upper strata of what geologists call the transition series, organic remains begin to appear,—first zoophytes, and then plants and animals. Animal remains abound chiefly in the upper or tertiary series, while vegetable remains abound

chiefly in the coal measures, that is, in the strata of the secondary or carboniferous series.

The most abundant of all vegetable remains are those of fossil Ferns, many of which are altogether unlike the Ferns that now exist, both in specific character and in magnitude. Next to Ferns, Pines and Palms are the most abundant, whether in the coal measures or in the strata above them. And if coal is wholly of vegetable origin, as is very generally believed, what ingredient could be better fitted to enter into its composition than the pitchy Pine? Upon the whole, Botanists enumerate about five hundred species of fossil plants found chiefly in the coal measures, and consisting chiefly of Ferns, Pines, Palms. On this subject let the student consult the *Prodromus* of Brongniart, or the *Fossil Flora* of Lindley and Hutton.

When the above fossil plants were in their state of growth, they must have been exposed to the influence of the atmosphere of their epocha, rooted in the strata immediately beneath them. Yet these strata afford nothing of soil, and consequently nothing of carbon, the principal food of plants. Whence, then, did the plants derive their nourishment? Where, and in what state, did the carbon exist? for it is evident, from the remains that have been found, that they grew both luxuriantly and abundantly.

To solve this question, Brongniart has suggested a very ingenious and a very plausible hypothesis. According to him, the carbon existed in their atmosphere in the state of carbonic acid gas, but in a much greater proportion than that in which it exists in the atmosphere of the present epoch, rendering it totally unfit for the respiration of animals, which had not yet, of course, begun to exist. But it was on this very account more fit for the food of plants, as it has been found by Saussure that plants thrive better in an atmosphere containing 10 or 12 parts in the 100 of carbonic acid gas, than in the atmospheric air of the present epoch. Hence the increased luxuriance of plants of the coal formations, though deriving no nourishment from the soil, and hence the conversion of the superabundant carbon of the medium in which they grew, from the gaseous to the solid state; depurating the atmosphere gradually for the respiration of the several and successive tribes of animals, as well as preparing a food that animals might assimilate; and finally, a paradise for the reception of man.

FOVILLA.—The effluvium that escapes from the granules of pollen when they burst, has been called the fovilla. If viewed with common magnifiers, it appears like a turbid fluid; but if viewed with magnifiers of the highest power, it is found to consist of multitudes of minute molecules moving on their own axis with great rapidity, the largest not exceeding $\frac{1}{5000}$ part of an inch in diameter. [Lind. *Introd.* 134.]

FOX-TAIL ROOT.—If a woody root finds its way into water, it is apt to protrude thousands of fine filaments from an elongated axis, assuming in the aggregate the appearance of the tail of an animal. It has been called the fox-tail root.

FRINGE.—The *peristomium*, or border of the mouth of the urn of the mosses, if ciliated, is denominated the fringe.

FRACTURE.—If a tree is bent so as to break part only of the cortical and woody fibres, and the stem or branch but small, the parts will again unite by being put back into their natural position, and well propped up, but especially in the season of spring. Yet it will not succeed if the fracture is accompanied with contusion, or if the stem or branch is large; and even where it succeeds, the woody fibres do not contribute to the union, but the granular and herbaceous substance only, which exudes from between the wood and liber, insinuating itself into all interstices, and finally becoming indurated into wood. Thus it resembles the *callus* that is formed in the union of broken bones.

FROND.—The frond is to be regarded as a union or incorporation of the leaf, leaf-stalk, and branch, or stipe, forming as it were but one organ, of which the constituent parts do not separate spontaneously from one another by means of the fracture of any natural joint, as in the case of real leaves, but adhere together even in their decay. It is exemplified in the tribe of Ferns.

FRONDESCENCE.—The leafing of plants was denominated by Linnæus their frondescence.

FRUIT.—In the progress of fructification, when the several organs of the flower have discharged their respective functions, the petals, the stamens, the style, and often also the calyx, wither and fall.

“Nec viola semper, nec hiantia lilia florent,
Et riget amissa spina relictæ rosa.”

OVID. DE ART. AM. Lib. xi. 115.

The ovary alone remains attached to the plant, and swells and expands till it reaches maturity. It is now denominated the fruit. In popular language, it is confined chiefly to such fruits as are esculent, as the Apple, the Peach, and the Cherry; but with the botanist, the matured ovary of every flower, together with the parts contained, constitutes the fruit. Hence the position of the fruit upon the plant will be the same as that of the flower which preceded it; axillary, if the flower was axillary; terminal, if the flower was so. The figure of the fruit exhibits a great variety of modifications, which it would be tedious to enumerate. But the spherical, or elliptical, or cylindrical forms are,

perhaps, the most common. The size of the fruit is also very various, but not at all in proportion to the plant producing it. The Oak and the Ash, though amongst the largest of trees, bear a fruit that is comparatively small; while the Gourd, whose stem is but herbaceous, and creeping, produces a fruit of a most enormous bulk. The surface of the fruit is very generally smooth, and in many cases exquisitely coloured; so that the beauties of the departed flower have but given way to the beauties of the ripened fruit; the mellow tints of autumn being equally pleasing with the bloom of spring; and the complexion of the peach and apricot being nothing inferior to that of the blossom that preceded them.

“Cum decorum mitibus pomis caput
Autumnus arvis extulit;
Ut gaudet, insitiva decerpens pyra
Certantem et uvam purpuræ.” HOR. EPOD. xi. 17.

Fruits may be regarded as composed of two distinct and constituent parts,—the pericarp and the seed. The pericarp is the exterior portion of the ripened ovary, constituting for the most part its principal mass. Pericarps are distributed by botanists into the following species, and yet the terms are equally employed to denote the fruit also—the capsule, the *pomum* or apple, the berry, the drupe, the silique, the legume, the cone. The capsule is a dry and membranaceous fruit or pericarp, separating when ripe into valves, as in *Primula*. The *pomum* is a fleshy pericarp or fruit enclosing a capsule, as in the familiar case of the Apple or Pear. The berry is a soft and pulpy fruit or pericarp, containing one or more seeds, but not enclosing a capsule, as in the genus *Ribes*. The Drupe is a soft and pulpy fruit or pericarp, enclosing a nut. It is exemplified in what is called stone fruit. The silique and legume are pods or fruits of different species, the former exemplified in the pod of Shepherd’s Purse; the latter, in that of the pea or bean. The cone or strobile is the indurated scales of the catkin. It is the fruit of the genus *Pinus*.

The seed, the last and most noble part of the fruit, is the interior portion of the ripened ovary, contained within the pericarp, and containing the rudiments of a new plant similar to that from which it sprang. In the pea and bean, it is that part of the fruit which is eaten; in the apple it is that part which is rejected, and lodged within the core. Its figure, like that of the flower and fruit, is very much diversified. It is globular, or egg-shaped, or oblong, or kidney-shaped, or lenticular. Its magnitude is estimated by means of four cardinal points, instituted by botanists, and serving as a gauge or standard, through the application of which it is regarded as being large, middle-sized, small, or

minute. It is large if it exceeds an inch in diameter, as the Coconut; middle-sized, if it ranges from an inch to two lines, that is, from the Hazel-nut to the Millet-seed; small, if from two lines to half a line, as in Papaver or Campanula; and minute, if smaller than the preceding size, as in Orchis. It is smooth as in *Linum*, furrowed as in *Vinca*, or wrinkled as in *Dianthus inodorus*, and is susceptible of the same modifications of shade as the flower and fruit. In *Pæonia* it is of a deep or dark purple; in *Croton cyanospermum* it is of an azure blue; in *Abrus precatorius*, it is of a rich scarlet; and in *Coix* it is white as snow. On the exterior of the seed, and at the point of its attachment to the pericarp, there is always to be found a mark or scar, differing in colour and in grain from the rest of the surface. It is the scar left by the natural fracture of the umbilical cord. Linnæus applied to it the appellation of the *Hilum*, which the term scar translates.

FRUTEX.—If a woody plant begins to send up its branches immediately from the surface of the soil, without attaining to any great height, and without a main stem, it is designated by the term *frutex*, which signifies a shrub.

FUNICULUS.—If the ovulum is attached to the placenta by means of a small thread, that thread is called the *funiculus umbilicalis*, or the umbilical cord.

FUNGI.—The Fungi, or Mushrooms, are a tribe of plants whose herbage is a frond of a fleshy or pulpy texture, quick in its growth and fugacious in its duration, and bearing seeds or gems in an appropriate and exposed membrane, or containing them interspersed throughout its mass. Plants of this tribe are usually regarded as the lowest in the scale of vegetable being, and as exhibiting a considerable resemblance to the animal tribe of zoophites. The stations which they affect differ as the species differs. Some we find on the surface of the earth; some buried under it; others on stumps or trunks of rotten trees; others on decayed fruit, as the Mucors; others on damp and wet walls; and others on animal ordure.

Many of the Fungi are altogether destitute of a root, or at least of any conspicuous root, being attached to some appropriate basis of support merely by means of a flattened adhesive portion of their surface. If any of them exhibits a root, it is nothing more than a few fibres. The frond is thin and flat, or globular, or bell-shaped, as in *Nidularia*, and adherent to a basis without any pedicle. But in a variety of species it is furnished with a stipe, solid or hollow, cylindrical or compressed, from the size of a crow-quill to an inch or more in diameter, and from being almost sessile to six or eight inches in height. Of the stipitate Fungi many are surmounted with a sort of

conical production called the *pileus* or cap, as in *Agaricus campestris*. Its upper surface is generally smooth, though sometimes wrinkled; generally of a white or yellow colour, but often of a beautiful red, as in *Agaricus muscarius*, or Fly Fungus. The under surface is furnished for the most part with a number of thin and flat plates, resembling in form the gills of a fish, and designated by the same name. Some have the additional appendage of a veil or curtain enclosing the gills in the early stage of their growth; and some have the appendage of a wrapper enveloping the whole of the frond.

If the inner surface of the curtain is carefully examined with a good magnifier, before the time of its natural detachment from the pileus, it will be found to be furnished with a multitude of fine and delicate threads supporting small globules: these Hedwig regards as the stamens. If the gills are next examined in the same manner, and about the same period, the surface will be found to be furnished with a number of small, tender, and cylindrical substances, each surmounted with a small globule. These he regards as being, probably, the styles and summits. But however this may be—for the existence of styles and stamens is by no means proved—the gills do eventually, and in their ripened state, discharge spontaneously multitudes of small and minute granules, whether seeds, gems, or sporules, by which the species may be propagated. Let any one put a sheet of white paper under a frond about the time that it reaches maturity, and he will soon find it covered with a fine and brown powder discharged from the gills in great abundance. In *Boletus* this receptacle is the tubes; in the *Mucors* it is the globule surmounting the stipe; in *Peziza* it is the upper surface of the frond only; and in *Clavaria* it is the general superficies.

The above view of the herbage and fructification of the Fungi embodies what had been received and regarded as orthodox by, perhaps, the generality of botanists, from the period of the investigations of Hedwig till that of the investigations of Beauvois and Cassini on the same subject; but more recently revived and illustrated by Messrs. Dutrochet and Turpin, in the *Annales du Museum*, T. III. Liv. i., 1834. The respect in which these investigators differ from Hedwig regards the herbage chiefly—that is, the primary and rudimentary state of the plant, and first stage of its existence. At best, Hedwig gives the Fungi no root but a few scattered fibres; and no herbage, distinct from the fructification, beyond that of a stem, where the species is furnished with a stem, as in the Agarics. But Dutrochet and Turpin, with the other above-named botanists, give them a herbage consisting of a reticulated and subterranean *Thallus*, similar to that from which *Agaricus Campestris* springs, which is a good example,

and which we have described at the article FAIRY RINGS. Further, the above botanists regard this thallus as a *Byssus*, not in the ordinary acceptation of the term,—that is, as constituting a distinct genus of the tribe in question, but as being merely the herbage of an Agaric or other congener, of which the Fungus proper is the fructification—the eatable Mushroom being merely the fructification of *Byssus parietina*. But at this rate the genus *Byssus* ought to be expunged from our systems entirely, and the several species of which it consists sunk in the peculiar species of Fungus to which they give origin. We believe that practical botanists are not yet prepared to adopt a change so violent, and that further investigations are necessary to establish the hypothesis. For though the genus may no longer appear in the new arrangements of the Fungologists of the present day, yet the species remain, and are introduced into their systems under the head of one genus or other. They are not struck out of the list of individual plants, or degraded to the rank of mere organs, or *thalli*.

Some species of *Fungi* are extremely detrimental to our growing crops of wheat, barley, and oats, lodging and vegetating in the leaf or in the ear, and causing smut, blight, mildew, rust; but others are of excellent use, whether in the arts or in dietetics. The powder of the Lycoperdons is said to be an excellent styptic, and is remarkable for its property of strongly repelling moisture. If a basin is filled with water, and a little of the powder strewed upon the surface so as to cover it thinly, the hand may be plunged into it, and thrust down to the bottom without being wetted with a single drop of the fluid. Several of the Boleti make a very good tinder. The Truffle is much esteemed for the rich and delicate flavour which it imparts to soups and sauces; and the mushroom is known to every lover of good things, not only for its esculent property in its entire state, but also for its excellent utility in the preparation of catsup. But in the gathering of such as are esculent, great care ought to be exercised by the gatherer, as much mischief may arise from a mistaking of the species, many of the Fungi being highly poisonous.

“*Pratensibus optima fungis*

Natura est; aliis male creditur.”—HOR. Lib. II. Sat. iv. 20.

We regard the late arrangements introduced into this immense order of Cryptogamic plants through the labours of modern botanists, whether continental or British, among which last Greville, Berkeley, and Hooker, stand conspicuous, as having thrown a light upon the subject of the Fungi that will render all future investigation comparatively easy, and perhaps allure to the study many to whom former difficulties might have seemed insurmountable.

GALBANUM.—This substance is a gum-resin obtained in the shape of small tears, from the milky juice of *Bubon Galbanum*, a perennial found at the Cape of Good Hope. Its colour is yellow, its taste acrid, its odour alliaceous. Water, vinegar, and wine dissolve the greater part of it, but the solution is milky. It is used in the composition of ointments and plasters.

GALLS.—Galls are tumours or excrescences caused chiefly by the puncture of insects of the genus *Cynips*. The object of the insect is the finding of a suitable *nidus* for the deposition of its eggs, which it injects with a drop of an acrid fluid that corrodes the adjacent parts, and causes the vegetable juices to accumulate around the deposit, till they are converted into a spongy lump. The lump thus formed is a gall. See BUNCHES AND TUMOURS.

GAMBOGE.—This substance is a gum-resin, the produce of *Garcinia Cambogia*, a tree which grows in India. It is brought to Europe in large cakes. Its colour is yellow, its fracture vitreous. It has no smell, and very little taste. It is soluble in alcohol. In medicine it is a violent cathartic.

GAMOSEPALOUS.—A term employed by some botanists to denote that union of sepals by which a calyx seems to consist of merely a single expansion.

GANGRENE.—Of this disorder there are two varieties, the wet and the dry. In the wet gangrene the diseased part becomes, first, soft and moist, and then dissolves into a foul ichor. It is confined chiefly to leaves, flower, and fruit. It may arise from too wet or from too rich a soil, or it may originate in contusion, as in the case of Peaches and Apricots. The dry gangrene attacks the leaves and young shoots, causing them to shrink and to shrivel up, and converting them from green to black. It may be occasioned by excessive heat, or by excessive cold, as in the case of young potatoe-tops nipt by morning frosts; or it may be caused by the too rapid growth of a particular branch, or by means of the attacks of parasitical *fungi*, as in the case of the bulbs of Saffron, which are often infested by a species of *Lycoperdon* that totally destroys them.

The Nopal, *Cactus Coccinellifer*, is subject to a disease which Thiery calls *La Dissolution*, but which seems to be the dry gangrene of Willdenow. Its progress is extremely rapid, and the part which it attacks is soon destroyed. Now it is verdant and shining, and in an instant its brilliancy is gone. It has changed from green to yellow, has lost all cohesion of parts, and is absolutely rotten. The only remedy is speedy amputation below the diseased part.

GAPS.—Gaps, according to Mirbel, are empty, but often regular and symmetrical spaces formed in the interior of the plant by means

of a partial disruption of the membrane constituting the tubes or cells. They are equivalent to what Kiesser calls Air Cells—which see.

GASES.—The agency of the gases as employed in the process of vegetation is, comparatively, but a late discovery, consequent upon the application of pneumatic chemistry to the illustration of the vegetable physiology. The gases constituting the air of the atmosphere are as essential to the life of the vegetable as they are to that of the animal. The mode of their operation, and the extent to which their action is beneficial, are discussed under the heads of—**GERMINATION** ; **THE ELABORATION OF OXYGEN**, and of **CARBONIC ACID** ; and **THE FOOD OF THE VEGETATING PLANT**.

GEMS.—Gems, from the Latin term *gemma*, a bud, are organized productions issuing from the surface of the plant, and containing the rudiments of new and additional parts which they protrude, or of new individuals which they constitute, by detaching themselves ultimately from the parent plant, and fixing themselves in the soil. According to Gærtner they are of two sorts, simple and compound,—simple, if furnished with only one envelope,—compound, if furnished with two or more envelopes. The latter includes the bud and bulb ; the former the *Propago* and *Gongilus*, equivalent to the spores or sporules of modern botanists, all of which will be found in their respective and alphabetical places.

GENERA.—What species are to individuals, genera are to species. A species is a group of individuals connected together by certain obvious and unequivocal resemblances in the form and structure of their several parts or organs, but differing, by some striking and peculiar trait, from all the other groups of allied individuals that may happen to belong to the same genus. Thus *Primula elatior* is distinguished from *Primula veris*, merely by a peculiarity that occurs in the border of the corolla. In the former the border is flat, in the latter it is concave. A genus is a group of species connected together by certain obvious and unequivocal resemblances in the form and structure of their several parts or organs, but differing, by some striking and peculiar trait, from all the other groups of allied species that may happen to belong to the same order. Thus the genus *Malva* admits only such species of Malvaceæ as have the exterior calyx trisepalous ; excluding all such as have it merely three-cleft, which it assigns to *Lavatera*.

Yet the limits of genera are not so well defined as those of species. Hence it has been generally held that species are absolutely and indubitably the work of nature ; while genera and the higher divisions have been regarded by many as being merely conventional groups instituted for the purpose of facilitating arrangement. Still the resem-

blance must be close and striking. Tournefort was the first to construct and exhibit good and legitimate models of generic grouping. Linnæus improved upon the principles of Tournefort, and laid down a number of valuable rules for the construction of genera, drawing his characters from the fructification only,—an example which modern botanists have pretty generally followed, or departed from only in some rare cases, admitting that the character does not form the genus, but the genus the character. [Philos. Bot. 119.]

GEOGRAPHY.—In surveying the surface of the earth which we inhabit as adorned with its gay covering of vegetables, one of the first facts coming under the notice of the observer is, that all plants do not vegetate in all habitations. Some are peculiar to certain soils; some to certain countries or continents; and some to certain climates, or parallels of latitude, of all countries, and of all continents. This has been called the geography of plants. It has not yet received from botanists all the attention which it deserves; but we are indebted for much of valuable and interesting remark upon the subject to Humboldt, Brown, and Decandolle.

The geography of plants affecting terrestrial habitations depends chiefly on climate, whether as resulting from latitude, or from altitude; under which heads there will be found a variety of important remarks furnished by Tournefort, by Humboldt, or by other botanical travellers; from which it follows that the distance of a few degrees of latitude effects, for the most part, a very material change in the character of the vegetable productions found at the extreme parallels. Hence each country or continent has a Flora that may be said to be peculiar to itself; or, it gives a peculiar cast of feature to plants of the same species; in the same manner as climate or country gives a peculiar cast of aspect and of colour, not merely to the several tribes of brute animals, but even to the several tribes of mankind. On this last particular, botanists have made the following remarks. Asiatic plants are remarkable for their superior beauty; African plants for their thick and succulent leaves; American plants for the length and smoothness of their leaves; and European plants for their lack of beautiful flowers, many of them being amentaceous. Plants indigenous to polar and mountainous regions are generally low, with compressed leaves. Plants indigenous to New Holland are distinguishable for small and dry leaves that have often a shrunk and shrivelled appearance. In Arabia their indigenous plants are chiefly low and dwarfish; in the Grecian Archipelago they are shrubby and furnished with prickles; while in the Canary Islands many plants, which in other countries are merely herbs, assume the port of shrubs and trees.

But the peculiarities of Floras are not confined merely to traits of

external aspect. They depend chiefly upon the presence or absence of certain distinct species, in certain given districts. Thus America has but few plants that are identical with those of the other great continents of the world, and even among them each has its own peculiar Flora. The Flora of Africa is different from that of Asia, and the Flora of Asia from that of Europe; while the Flora of New Holland is palpably distinct from all other Floras on the face of the earth. Take these continents in their several grand divisions, and you have the same peculiarities. The Floras of China, of India, of Tartary, of Siberia, of central and oriental Europe, of central and southern Africa, are all distinguished by similar discrepancies. At the Cape you have the Heaths, and the Geraniums, which abound chiefly in that locality, together with the Proteaceæ which abound chiefly in that locality or latitude. [Lin. Trans. vol. X. part i.] On the continent of America you have the Bromeliaceæ exclusively; in the Indian Archipelago, you have cloves, cinnamon, nutmegs, exclusively; and in the small island of St. Helena, out of upwards of sixty indigenous species, you have only two or three that are known to belong to any other island or region of the world. Some plants seem to affect certain longitudes. Thus on the east side of the rocky mountains that traverse North America longitudinally, the landscape abounds in Azaleas, rododendrons, magnolias, and oaks; while on the west side of the same ridge, these genera are but rarely to be met with. [Lind. Introd. 489.]

The following comparative view of the proportion which the acotyledons and monocotyledons bear to the mass of the dicotyledons, in the equatorial, temperate; and frozen zones, is taken from the table drawn up by Baron Humboldt. In the torrid zone the acotyledons are as $\frac{1}{15}$; in the temperate zone as $\frac{1}{2}$; in the frozen zone as $\frac{1}{4}$. In the torrid zone the monocotyledons are as $\frac{1}{3}$ or $\frac{1}{6}$; in the temperate zone as $\frac{1}{4}$; in the frozen zone as $\frac{1}{2}$. How came these plants to the habitations or to the stations which they now occupy? Some have been transported, no doubt, by the agency of wind or wave, and some by the agency of man. But we shall have offered no violence to the sacred text, if we suppose that they sprang up spontaneously and originally in the localities where they are now found; or in consequence of the operation of causes connected with the constitution of this globe which are to us a mystery. "And God said, Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself upon the earth; and it was so." [Gen. i. 11.] [See CLIMATE, LATITUDE, ALTITUDE.]

GERM.—The embryo of the seed is sometimes called the germ of the seed; and the plural of the term was used formerly by Duhamel

to signify those latent and rudimentary molecules which he regarded as being dispersed throughout the whole of the plant for the purpose of giving origin to buds, whether of root or of branch, wherever buds were wanted, and which he denominated pre-organized germs.

GERMEN.—This term, which was introduced by Linnæus, seems to be, now, superseded by that of the term *ovary*, the base of which it was intended to designate.

GERMINATION.—Germination is that act or operation of the vital energies of the organs of the seed, by which the embryo is extricated from its envelopes, and converted into a plant. This is universally the first act of the process of vegetation. For it may be regarded as an indubitable fact that all plants spring from seed, or from organs equivalent to seeds; the doctrine of equivocal generation being now most completely exploded, and an additional proof adduced of the uniformity of the operations of nature. But seeds will not germinate at random, and in all circumstances whatever. They will germinate only on certain conditions; and till such conditions take place the vital energy lies dormant in the substance of the seed. But when a seed is placed in the soil, or under circumstances favourable to vegetation, its vital energies are immediately stimulated into action, producing a variety of combinations, and effecting a gradual change in the parts of the seed. The radicle is converted into a root; the plumelet into a trunk or stem with its leaves and branches; and a new plant is formed capable of extracting from the soil or atmosphere the food necessary to its growth and developement. What are the conditions necessary to germination; and what the phenomena resulting from it? For the conditions of germination, see that article;—and for the phenomena let us take them, first as physical, and secondly as chemical.

I. When a seed is committed to the soil under the proper conditions, it begins soon after to inhale or to imbibe air and moisture, and to expand and augment in volume. This is uniformly the first symptom of incipient germination, though not always an infallible symptom; because the seed may swell with moisture merely by soaking it in water, though its vitality should be totally extinct. But the first infallible symptom and first indubitable step is the prolongation of the radicle beyond the extent to which it would attain merely as a consequence of soaking. In the latter case the augmentation of the radicle is limited by the extent and capacity of its envelopes, or by the quantity of moisture necessary to its saturation, or by causes inducing incipient putrefaction. In the former case its augmentation is circumscribed by no such limits, but forwarded by gradual and additional increments resulting from the actual assimilation of nutriment, causing it to burst its integuments, and to direct its extremity downwards into the soil.

The next step in the process of germination is the evolution of the cotyledon or cotyledons, unless the seed is altogether acotyledonous, or the cotyledons hypogean.

An additional step, in the case of seeds furnished with cotyledons, is that of the extrication of the plumelet, or first real leaf, from within or from between the cotyledon or cotyledons, and its expansion into the open air.

The last and concluding step in the process of germination is the developement of the rudiments of a stem, if the species is furnished with a stem, and the plant is complete.

The above general remarks are founded on the following particular observations. In a season the most favourable to vegetation Malpighi sowed some seeds of the Gourd. At the end of the first day they were considerably swoln, and the envelopes so much moistened that a fluid oozed out of them when pressed with the finger. A hole was also discoverable in the envelopes at the summit of the seed, through which the moisture seemed to be conveyed to the cotyledons, which had already begun to assume the form of seminal leaves. At the end of the second day the interior membrane seemed to be somewhat torn, and the plantlet somewhat extended, exhibiting, on a transverse section taken about the middle, longitudinal fibres, and tracheæ, as well as cells, bark, and pith. The radicle was also distinctly visible. At the end of the third day the exterior membrane had become more brownish, and its cells more extended; the radicle had burst its integuments, and the plumelet had begun to expand. At the end of the fourth day the plantlet had perceptibly augmented in size. The radicle was covered with protuberances from which the lateral fibres were to issue, and the interior envelope was somewhat shrivelled, but covering still the seminal and other leaves, in which nerves were now perceptible. At the end of the sixth day the leaves of the plumelet had escaped from the seed, though still contained within the cotyledons, being soft, but perceptibly covered with hairs. At the end of the ninth day the plantlet had wholly escaped from its integuments, though the plumelet was still contained within the seminal leaves, yellowish in its appearance, but gradually assuming a tinge of green. At length its extrication was effected, and the radicle converted into a root, and the rudiments of a stem developed; and on the twentieth day the plant was complete. [*Anat. Plant. Pars Altera.*]

By what medium does the absorbed moisture enter the seed? Gleichen instituted some experiments from which he concluded that it enters by the scar only; yet we cannot doubt that it enters partly by the foramen also, and partly by the surface of the envelopes. Further, is the moisture transmitted immediately to the plantlet, or is it

transmitted to it through any particular channel? It was early suspected that the moisture destined to give developement to the plantlet is transmitted to it chiefly through the medium of the cotyledons. This opinion was founded upon the apparent adaptation of the cotyledons both to absorb and to transmit moisture, in consequence of their soft and fleshy texture, and of the vessels dispersed throughout their substance, which Grew regarded as the seminal root. [Anat. of Plants b. i. sect. 24.] They are sometimes visible even before germination has been begun; but particularly after it has made some progress. On the surface of a transverse section of the well-soaked lobes of a bean, they may be seen in the form of small spots or specks; and on the longitudinal section, or even on the natural and inner surface of the lobes, their various ramifications may be traced, converging and uniting as they approach the radicle in which they terminate.

The above presumption was afterwards confirmed by experiment. Germinating seeds were moistened with a coloured fluid by Gleichen, Bonnet, and Senebier respectively, who found, as the result of their several experiments, that the fluid had tinged the vessels of the lobes, and through them passed on to the radicle. Also it was found that seeds deprived of their cotyledons will not germinate at all. Hence it follows that the nutriment necessary to the developement of the plantlet either exists originally in, or passes intermediately through, the cotyledons, till it ultimately reaches the radicle. Eller is said to have maintained that there are also other vessels in the seed passing immediately from the cotyledons to the plumelet. But Hedwig could not find them; and as the radicle is always unfolded the first, and the plumelet only in a subsequent stage, it is probable that such vessels do not exist. Hence we conclude that the plumelet receives its nutriment from the radicle, as the radicle from the cotyledons; and yet it is certain that the plumelet is sometimes developed even where the radicle has been apparently quite destroyed, either before the sowing of the seed, or immediately after its incipient germination, as in the case of seeds attacked by mice or by insects, either in the granary or in the soil; though this is by no means the most singular circumstance relative to the developement of the organs in question. The constant and unerring uniformity with which the radicle and plumelet exert themselves, respectively, to gain the position and situation best suited to their future growth, is a phenomenon exhibiting more that is calculated to excite the admiration of the phytologist. [See DIRECTION OF THE RADICLE AND PLUMELET.]

II. The chemical phenomena of germination consist chiefly in the changes that are effected in the nutriment destined for the support and developement of the embryo till it is converted into a plant. It was

already shown that this nutriment either passes through the cotyledons, or is at least contained in them; because the embryo dies when they are prematurely cut off. But the farinaceous substance of the cotyledons, at least in exalbuminous seeds, is a proof that they themselves contain the nutriment. They are to be regarded, therefore, as repositories of the food destined for the support of the embryo in its germinating state. Or if the seed is furnished with a distinct and separate albumen, then is the albumen to be regarded as the repository of food, and the cotyledon or cotyledons as the channel of its conveyance. But the food thus contained in the albumen or cotyledons is not yet fitted for the immediate nourishment of the embryo. Some previous elaboration is necessary—some change preparatory to its introsusception; and that change is effected through the intervention of chemical agency.

It has been shown in the foregoing pages that a seed is no sooner placed in the earth than it begins to imbibe moisture. But the moisture thus imbibed is immediately absorbed by the cotyledons or albumen, which it readily penetrates, and on which it immediately begins to operate a chemical change, dissolving part of their farina, or mixing with their oily particles, and forming a sort of emulsive juice. The consequence of this change is a slight degree of fermentation, induced, perhaps, by the mixture of the starch and gluten of the cotyledons in the water which they have absorbed, and indicated by the extrication of a quantity of carbonic acid gas, as well as by the smell and taste of the seed. [Seneb. Phys. Veg. iii. 408.] This is the commencement of the process of germination, which takes place even though no oxygen gas is present. But if no oxygen gas is present, then the process stops; which shows that the agency of oxygen gas is indispensable to germination. [Thomson's Chem. iv. 374.]

Accordingly, when oxygen gas is present it is gradually inhaled by the seed, and the farina of the cotyledons is found to have changed its savour. Sometimes it becomes acid, but generally sweet, resembling the taste of sugar, and is consequently converted into sugar, or some substance analogous to it. [Sauss. Sur la Veg.] This is a further proof that a degree of fermentation has been induced; because the result is precisely the same in the process of the fermentation of Barley when converted into malt, as known by the name of the saccharine fermentation, in which oxygen is absorbed, heat and carbonic acid evolved, and a tendency to germination indicated by the shooting of the radicle. The effect of oxygen, therefore, in the process is, that of converting the farina of the albumen or cotyledons into a mild and saccharine food, fit for the nourishment of the infant plant, as well as very palatable to many animals. Hence the depredations committed upon many germinating seeds by mice, or by insects.

In what manner does the oxygen operate, and on what principles of the seed does it act? Does it act merely as a stimulant to principles which the seed already contains;—does it form a combination with the substance of the seed, and thus identify itself with the germinating embryo; or does it abstract from the seed any particular principle of its composition, and so effect the change that follows? The suppositions involved in these questions have each had their defenders and opponents, though there is now, as I believe, but one opinion on the subject. Humboldt thought that the oxygen acts merely as a stimulant, because seeds seemed to germinate faster in an atmosphere of pure oxygen gas, than in common air; but particularly when steeped in water impregnated with oxymuriatic acid. But as oxymuriatic acid gas—the *Chlorine* of modern chemists—is now known to contain no oxygen, the argument, as far as oxygen is concerned, is inconclusive. Chlorine seems indeed to act as a stimulant, but the experimenter ought to be very cautious in his application of it; for if applied in large doses, it will infallibly destroy the vitality of the seed. M. Rollo was of opinion that the oxygen consumed in the process of germination is in part absorbed by the grain, and assimilated to its substance, and in part employed to form carbonic acid with the carbon of the seed.

But the volumes of the respective gases inhaled and evolved had not yet been compared. Yet this comparison was indispensably necessary to the elucidation of the subject, and it was ultimately accomplished by Saussure the younger. Lavoisier had shown that oxygen in combining with carbon by combustion undergoes no alteration of volume. But the result must be the same as they combine in the germinating seed. Hence the clue was given that led to the discovery of the fact. If the quantity of oxygen consumed was greater than the quantity of carbonic acid evolved, it was to be inferred that a portion of oxygen had been assimilated to the substance of the seed; but if the quantities were equal, then the contrary was to be inferred. In an atmosphere of 100 cubic inches of common air, known to contain about 21 cubic inches of oxygen and 79 of nitrogen, when peas, beans, barley were made to germinate, it was found that if fourteen cubic inches of carbonic acid gas were formed during the process, seven cubic inches of oxygen remained uncombined in the atmosphere; and if seven cubic inches of carbonic acid gas were formed during the process, then fourteen cubic inches of oxygen gas remained uncombined in the receiver. [Sur la Veg. chap. i. sect. 3.] Thus the quantities inhaled and evolved were found to be equal; establishing the fact, that there is no actual fixation of oxygen in the process of germination; and that the oxygen inhaled is employed solely for the

purpose of diminishing the proportion of carbon contained in the seed, and, by consequence, of augmenting that of its oxygen and hydrogen—principles which it is also known to possess.

In repeating the experiments of Humboldt, Saussure did not find any perceptible difference in the periods of germination, whether the seeds were placed in an atmosphere of pure oxygen or of common air. Different species of seed required different doses of oxygen to excite or to accelerate their germination; but the application of carbonic acid in almost any proportion seemed but to retard it. Further, Saussure found that seeds will not germinate in mediums deprived of oxygen; if they have been known to germinate in water, or in the vacuum of an air-pump, it is evident that their germination was effected merely in consequence of the uncombined oxygen yet remaining in the receiver that was not yet completely exhausted.

Such are the phenomena, physical or chemical, observable in the germination of the seed. Air and moisture are absorbed from the soil or atmosphere by the scar, foramen, or envelopes. Their agency is immediately exerted on the farina of the albumen or cotyledons, and a glutinous or mucilaginous food is thus prepared for the nourishment of the tender embryo, to which it passes through the medium of the vessels of the cotyledons, or, as they have been also denominated, the seminal root. The radicle gives the first indications of life, expanding, and bursting its integuments, and at length fixing itself in the soil. The plumelet next unfolds its parts, developing the rudiments of leaf, branch, and trunk; and, finally, the seminal leaves decay and drop off, and the embryo has been converted into a plant capable of abstracting immediately from the soil or atmosphere the nourishment necessary to its future growth.

GILLS.—The under surface of the pileus of the Fungi is furnished, for the most part, with a number of thin and flat laminae, which are attached to it at the one edge, and distributed like the radii of a circle. They are designated by the name of the gills. Sometimes they are inserted separately, and sometimes in pairs or sets, and sometimes they inosculate and grow into one another. They assume different shades of colour in different species, but in *Agaricus campestris* they are of a beautiful pink. Of Fungi not having gills some are furnished with a multitude of pores or tubes, as in *Boletus*, or with prickles, as in *Hydnum*.

GIRDLING.—Girdling is an operation to which trees in North America are often subjected when the farmer wishes to clear his land of timber. It consists in making two parallel and horizontal incisions quite round the trunk of a tree, so as to penetrate through the alburnum, and facilitate the scooping out of the intervening portion,

which is the last part of the operation. If this is done early in the spring, and before the commencement of the bleeding season, the tree rarely survives it; though some trees that are peculiarly tenacious of life, such as *Acer saccharinum* and *Nyssa integrofolia*, have been known to survive it a considerable length of time. [Barton's Elem. of Bot.]

GLANDS.—Glands are small and minute productions of various different forms, found chiefly on the surface of the leaf and petiole, but often also on the other parts of the plant, and supposed to be organs of secretion. This was at least the opinion of Linnæus, who defined the glands to be “a little tumour secreting a fluid” [Phil. Bot. sect. 84] which is in some cases no doubt the fact. From the extreme minuteness or apparent insignificance of vegetable glands, it was long before they attracted the notice of botanists, so as to be distinctly discriminated into species, and described according to their different forms. Yet this was at last effected by the industry of M. Guettard, a French physician and botanist, who first undertook the investigation of the subject, and characterized and distributed them as follows [Mem. del' Acad. Royal, 1761]:—

First, *Miliary Glands*,—so denominated from their supposed resemblance to the miliary glands of animals—glands usually described as resembling grains of Millet-seed. Sometimes they are crowded together in clusters, as in the Cypress, or arranged in regular sets, as in the leaves of the Fir.—Secondly, *vesicular glands*; which are and membranaceous substances resembling transparent bladders. They are found on the leaves of the Myrtle and St. John's-wort.—Thirdly, *Scaly glands*,—which are generally of the form of an oblong or circular scale, and are found on the frond of Ferns.—Fourthly, *Globular glands*,—which have the appearance of small and minute globules, and are found chiefly on plants with labiate flowers.—Fifthly, *Lenticular glands*,—that is, glands having the figure of a lens more or less elongated. They are found on the young shoots of many trees, but particularly of the Birch.—Sixthly, *Cup-shaped glands*, presenting a cavity in the form of a cup, and found on the petioles of the Nectarine and Passion-flower.

Glands are in some species sessile, as in the case of the Apricot; in others they are supported upon a pedicle, as in the several species of Rose. But though the petiole is that part of the leaf on which they are the most frequently situated; yet they are by no means confined to it. In the leaf of *Salix pentandra* they are situated between the serratures of the margin; in the leaf of the Tamarisk they are situated on the under surface; and in the leaves of Sundew, they originate in the upper surface. The glands of the Moss-rose and Birch-tree are situ-

ated on the stem and branch. The fluid which they secrete is in some cases resinous and fragrant, as in the Moss-rose; in others, it is a honied exudation, as in *Viburnum Opulus*. Linnæus seems to have regarded glands as affording good and legitimate marks of specific discrimination; but they do not appear to have been much resorted to by succeeding botanists.

GLANS.—The glans is a one-celled, mostly one-seeded, and indehiscent fruit or pericarp, seated in a sort of persistent involucre called a *cupule*. Sometimes it is single and partially naked, as in the acorn of the oak; and sometimes it is duplicate and completely enclosed in the *cupule*, as in Beech-mast or Sweet Chestnut.

GLOSSOLOGY.—This Greek compound is made use of by some writers to denote that department of botany which gives an explanation of technical terms.

GLUME.—Glume is the chaffy and membranaceous calyx of the Grasses. See CALYX.

GLUTEN.—If a portion of wheaten flour is made into a paste, and the paste well washed, by kneading it under a small stream of water, the water will ultimately carry off from it all the starch, and leave a *residuum* behind. This residuum is gluten. It is a tough, ductile, and elastic substance, of a dull white colour, without taste, but of a very peculiar smell. It is soluble in the acids and alkalies, slightly soluble in water, but not soluble in alcohol. [Davy's Agri. Chem. 74.]

When it is exposed to the action of the air, it gradually dries and hardens, and assumes a dark brown colour with a slight degree of transparency resembling glue, except that it is more brittle, and breaks like glass. When kept for some time in a place that is moist, it undergoes a species of fermentation, and swells and emits air bubbles which consist of hydrogen and carbonic acid gas. When exposed in a dry state to heat, it cracks, swells, and melts, and exhales a fetid odour, burning like horn or feathers. When distilled it yields ammonia, and an empyreumatic oil, and leaves a charcoal that is with difficulty reduced to ashes. The above properties of vegetable gluten indicate its relation to animal gluten, particularly the phenomena of its fermentation and destructive distillation, by which it is found to contain as one of its constituent principles, a portion of nitrogen. [Thomson's Chem. vol. iv.]

Gluten has been detected, under one modification or other, in a very considerable number of vegetables or vegetable substances, as well as in the flour of wheat. Proust found it in peas, beans, barley, rye, acorns, chestnuts, apples, elder-berries, grapes. He found it also in the leaves of cabbage, and in the petals of the rose. It is undoubtedly one of the most important of all vegetable substances; and if wheat is better fitted for making bread than any other grain, it is owing to its containing a greater quantity of gluten.

Still it seems doubtful whether gluten ought to be regarded as a proximate principle of vegetables after all; for Dr. Taddei separates it, as it seems, into two other principles, by means of kneading it in alcohol,—one called *gliadin* or glue,—the other called *zimomin* or ferment. But we leave the solution of chemical doubts to the chemists themselves.

GONGYLUS.—The Gongylus, according to Gærtner, is a simple gem, or reproductive granule, peculiar to some tribes of imperfect plants, and exemplified in the Fuci. It consists of a slightly indurated pulp, moulded into a globule, and invested with an epidermis. Its use seems to be superseded by that of the term spore or sporule.

GRAFTING.—Grafting is an artificial application of a shoot bearing a bud, taken from one tree, and fitted to the stem or branch of another, so as that the two shall vitally coalesce and form but one plant. The shoot bearing the bud is called the graft; the stem to which it is affixed is called the stock.

As the graft is merely an extension of the parent plant from which it came, and not, properly speaking, a new individual, so it is found to be the best method of propagating approved varieties of fruit trees, without any danger of altering the quality of the fruit, which is always apt to be incurred in propagating from the seed. Some gardeners will indeed tell you that a rose grafted on a black currant will produce black roses, as if the stock affected the quality of the graft; but this is evidently a vulgar error. The graft will also bear fruit much sooner than a tree raised from seed, and, if effected on a proper stock, will be much more hardy and vigorous than if left on the parent plant. Hence the great utility of grafting—an art that has been long known to the botanist as well as to the practical gardener, whose province it is to specify the several sorts of grafts. But the grand secret of the art consists in fitting the graft to the stock by means of the grafting knife, so as that the liber of the one shall be applied to the liber of the other; for unless the two libers are brought into contact, the graft will not succeed. Nor will it succeed well except among plants having some natural affinity to one another, as the Plum and Cherry, in which, as in all other cases, the union is effected by means of a granular and herbaceous substance that exudes from between the wood and bark, binding and cementing together the stock and graft, though not uniting the section of the woody layers. But all succeeding layers of wood are produced entire as before, and if the operation is dexterously performed, it is sometimes difficult, after a while, to point out the place of the graft.

GUM.—Gum is an exudation that issues spontaneously from the surface of a variety of plants, in the state of a clear, viscid, and tasteless fluid, which gradually hardens upon being exposed to the action of the atmosphere, and condenses into a solid mass. It issues copi-

ously from many fruit-trees, but especially from such as produce stone-fruit, and chiefly from fissures in the bark—"dereptum cortice gummi." [Ovid.] Its principal varieties are Gum Arabic, Gum Tragacanth, Cherry-tree gum, and Mucilage.

Gum Arabic is the most plentiful of all the gums. It is the produce of *Mimosa nilotica*, a native of the interior of Africa and of Arabia, whence the name. In its concrete state, in which it assumes the shape of irregular globules, it is considerably hard, as well as somewhat brittle, and is destitute both of smell and taste; when pure, colourless and transparent, though sometimes it is tinged with yellow, varying in its specific gravity from 1300 to 1490. [Davy's Agri. Chem. Lec. iii.] It is insoluble in alcohol, but readily soluble in water; and if the solution is exposed to the action of the atmosphere, the water is gradually evaporated and the gum again left in a solid mass. According to Gay, Lussac, and Thenard, it consists of the following elements in the following proportions, 100 parts being the integer. Carbon 42.23, oxygen 50.84, hydrogen 6.93,—total, 100. [Trait. de Chim. Element.]

Gum Tragacanth is the produce of *Astragalus Tragacantha*, a thorny shrub that grows in the islands of the Levant. It differs from Gum Arabic in the shape assumed by the concreting mass, which is generally that of thin and channelled plates. It is also less transparent than Gum Arabic, and not so readily soluble in water.

Cherry-tree Gum is obtained from *Prunus avium*, and other species of the same genus, and generally from all trees with stone-fruit, from which it exudes spontaneously, and in great abundance. It differs from Gum Arabic and Tragacanth in its concreting in larger masses, and in being more easily melted.

Gum in the state of Mucilage is found chiefly in the roots and leaves of plants, particularly such as are bulbous and succulent, as in the bulbs of the hyacinth, and the root and leaves of marsh-mallow. It is found also in Flax-seed, and in many of the Lichens, and is to be obtained only by maceration in water, from which it is separated by means of sulphuric acid. [Thomson's Syst. of Chem. vol. iv.]

Gum in all its varieties is capable of being used as an article of food, and is highly nutritive, though not very palatable. It is also of considerable utility in the arts, particularly in that of calico-printing, in which the artist employs it to give consistency to his colours, and to prevent them from spreading. The botanist often uses it to fix his specimens upon paper, for which purpose it is tolerably well adapted, though its use is being superseded by that of glue. It forms likewise an ingredient in ink; and in medicine it forms the basis of many mixtures, in which its influence is sedative and emollient.

HABIT.—Habit is the outward port or aspect of a plant, by which it is regarded, or readily recognised, as belonging to a certain tribe or family. It is that sort of resemblance which strikes the eye of the beholder at first sight, without putting him to the trouble of enquiring in what it specifically consists. Hence the first arrangements of plants were founded chiefly on their external aspect or habit,—herbs, shrubs, trees,—palms, ferns, grasses. The habit of many plants is apt to be affected by soil, or by cultivation. Thus *Buxus sempervirens*, if planted in a poor soil, remains small and dwarfish; but if planted in a rich soil, it assumes the port of a tree. Thus also *Pyrus sativus*, when growing in a wild state, is furnished with strong thorns; but when transferred to a rich and cultivated soil, its thorns disappear. Professor Willdenow explains the phenomenon thus:—The thorns protruded in the uncultivated state of the plant are buds rendered abortive from want of nourishment, which, when supplied with a sufficiency of nourishment, are converted into leaves and branches.

HABITATION.—The habitation of a plant is that particular country or continent to which it is indigenous, and out of which it is not to be met with in an uncultivated state. Thus the natural habitation of *Magnolia grandiflora* is North America; but that of *Magnolia conspicua* is China.

HAIRS.—Hairs are small and thread-like productions which originate in the epidermis, and cover certain plants, or parts of plants, like the hairs of animals. In their aspect they are smooth and silky, as in *Sophora argentea*; or crisp and woolly, as in *Origanum Dictamnus*; or long and shaggy, as in *Galeopsis villosa*. In their structure they are awl-shaped, as in *Begonia nitida*; or hooked, as in Agri-mony; or forked, as in Lavender. Hairs constitute the most prominent species of vegetable pubescence, but are extremely apt to change their appearance from soil, exposure, or culture. Hence Linnæus regarded them as affording bad marks of specific distinction, and not fit to be employed except in cases of necessity. But cases of necessity have occurred. Sir J. E. Smith has employed them with success in distinguishing the several species of Mint; and Dr. Brown, in his “Elucidation of the Natural Orders of the Proteaceæ of Jussieu.”

HEAD.—The head is a species of inflorescence consisting of a group or assemblage of flowers distributed upon the extremity of the stem or branch, or general peduncle, and aggregated into a globular form, as in *Statice Armeria*. Perhaps the inflorescence of the *Compositæ* should be ascribed to this mode, though, doubtless, most of them are discoid.

HEAT.—Heat, in the popular acceptation of the term, signifies either the sensation which we experience on the approach of a heated body,

or the cause of that sensation. But to avoid all ambiguity, chemists designate the latter by the term caloric, and the former by the term heat. As a sensation, then, we can have no difficulty in acquiring a correct idea of heat. But what is caloric, or the cause of heat? This question has given rise to much discussion among philosophers, some maintaining that it is a real and material substance, existing every where, and combining with all other bodies; and others, that it is merely a vibratory motion of the constituent particles of material substances. It forms no part of our plan to enter into this discussion. But the advocates of the doctrine of emanation give the following account of its origin and effects:—

It radiates from the sun, or from heated bodies, and may be collected into a focus like the rays of light; or it is produced by percussion or collision, as when steel is struck with a flint; or by friction, as when two pieces of dry wood are briskly rubbed against one another; or by combustion, as in our common fires; or by mixture, as in many cases of chemical union:—Mix together four parts of sulphuric acid with one part of water, and put the hand to the glass containing it, and you will have a very sensible proof of the production of heat. It increases the bulk of all bodies into which it enters, with a few exceptions. A bar of iron heated to redness is longer and broader than it was when cold. It is the cause of fluidity: the very metals are converted into fluids, and the fluids into gases, by the application of heat; and as the dose of it which is necessary to convert them into that state is not sensible to the thermometer, it is hence said to be latent. But if the process is reversed, whether naturally or artificially, the caloric is again liberated, and again rendered sensible to the thermometer. When the thermometer rises above the degree that is quite comfortable to us, we say it is hot; and when it sinks beyond the like degree, we say it is cold; yet cold is nothing but the abstraction of caloric, which we cannot bear in its excess, and cannot live without.

Such are a few of the more obvious properties of heat or caloric; though it does not necessarily come within the scope of our present enquiries, except as connected with vegetation; but with that its connexion is very close.

I. It acts as a stimulant to the energies of vegetable life, and excites the several organs to their respective functions. If a seed is put into the soil during the colds of winter, it will lie there dormant till its energies are aroused by the returning warmth of spring, and then it will germinate, and sprout up into a plant. But when it has become a plant, it is still dependent for the growth and developement of its parts upon the agency of heat. The colds of autumn strip it of its

foliage; and the keener colds of winter suspend, or render inappreciable, the exercise of its vital functions. The plant may then be said to hibernate. It is a period of rest and repose, not less necessary, as we may believe, to the plant than to the animal. But when the warmth of spring and of summer suns returns, the bud swells and the leaf is protruded, together with the flower and fruit in due succession, weighing down both twig and branch.

“ Κατὰ ψύλλον, κατὰ κλῶνα,
Καθελὼν ἤνθησε καρπός.”

ANAC. Ode xxxvii.

Consult in illustration of this subject the following articles :—CALENDARIVM FLORÆ, HOROLOGIVM FLORÆ, EXCITABILITY.

II. It is generated in the process of the evolution of the seed, and often in that of the growth of the plant. In the well-known process of malting, which is neither more nor less than a partial and artificial germination, oxygen gas is absorbed as in the case of natural germination, while *heat*—that is, caloric—and *carbonic acid gas* are evolved. Whence came the caloric? It came, as there can be no doubt, from the combination of the absorbed oxygen with the carbon of the seed.

A similar evolution takes place at the time of the expansion of the flower of many plants. The phenomenon was first observed by Lamarck in the case of *Arum Italicum*. M. Decandolle says he has observed it often since. It occurs but once to each spadix, about the time of the opening of the spathe, commencing at about three o'clock in the afternoon, and reaching its maximum about six. Senebier found that it raised the temperature 7° of Reaumur beyond that of the surrounding atmosphere. Saussure observed the same phenomenon in the flowers of *Cucurbita Pepo*, *Cucurbita Melopepo*, and *Bignonia radicans*, and found that the degree of heat they produced was in proportion to the quantity of oxygen they consumed. [Dec. Phys. Veg. ii. 351.]

HEART-WOOD.—The central and circular layers of the stem of dicotyledonous plants, equivalent in its signification to the *Duramen*—which see.

HELMET.—When the upper lip of a labiate flower is conspicuously arched, as in *Lamium album*, it is denoted the Helmet—*galea*.

HEPATICÆ.—The Hepaticæ or Liverworts are a tribe of small and herbaceous plants resembling the mosses, but chiefly assuming the appearance of a frond, and producing their fruit in a capsule that splits into longitudinal valves. The name is derived from ἥπαρ, ἥπατος, signifying the liver; because perhaps some of them were formerly employed medically in diseases of the liver, or because some of them are composed of lobes exhibiting a slight resemblance to the lobes of

that organ. Their favourite stations are wet and shady spots by the sides and springs of ditches, or on the shelving banks of rivulets, or on the trunks of trees. Like the mosses they thrive best in cold and damp weather, and recover their verdure, though dried, if moistened again with water. They are, indeed, so nearly allied to the mosses that the two families were long regarded as constituting but one tribe; the latter under the title of *Musci Frondosi*, and the former under that of *Musci Hepaticæ*. Such was the division even of Hedwig; but later botanists have found it to be more consonant to the principles of sound arrangement to separate the Hepaticæ from the mosses altogether, and to make of each a distinct tribe.

Many of them have no root, or at least no conspicuous root, as in *Jungermannia asplenoides*; but where a root is present it is fibrous, issuing from the base or under surface of the herbage, and fixing it to the soil or substance on which it grows. In a few of them the herbage is a stem furnished with distinct leaves, and assuming a winged appearance; but in most of them it is frondose, though not upright, being seldom furnished with any thing like a stipe. Sometimes it is simple, and sometimes branched and furnished with a midrib or *rachis*, from the opposite sides of which the lobe-like leaflets issue. In *Marchantia polymorpha* the herbage is merely a cluster of circular and lobe-like substances growing out of one another, and lying flat on the ground, to which they attach themselves by fibres issuing from the under side. The structure of the lobes is extremely beautiful exhibiting, when placed under the microscope, a fine net-work of vesicles frequently transparent. Their colour is generally green; but in *Jungermannia dilatata* it is of a dark brown.

The fructification of the Liverworts is analogous to that of the mosses; but the parts corresponding to the stamens and pistils of perfect plants do not appear to have been hitherto ascertained so satisfactorily as to leave no room for doubt. According to Hedwig, the barren flowers are either small and globular protuberances issuing from the summit, or from among the leaflets, or from the surface of the frond, being *viscera* containing a powdery substance, which is the presumed pollen, as in *Jungermannia*; or in small and minute granules surrounded with succulent threads; or in target-shaped substances imbedded in the surface of the frond, or elevated on conspicuous pedicles as in *Marchantia*. The fertile flowers consist, for the most part, of a double envelope, or outer and inner integument, corresponding in some measure to the calyx and corolla of perfect plants. If a plant of *Jungermannia complanata* is taken and closely inspected even with the naked eye, in an early stage of its growth, a number of small oblong and sack-like-looking substances will be seen issuing from

among the leaflets, and assuming a position perpendicular to the surface of the frond. These sacks are the outer envelopes of the flower; and, carefully opened up, will be found to contain the inner envelope, masking both the style and ovary, which is yet a greenish mass interspersed with multitudes of minute granules.

If the flower instead of being thus dissected is allowed to ripen on the plant, the envelopes will, in the progress of fructification, burst open at the top, and discover a small protruding globule of a black or brownish colour, and of about the size of a millet seed, which is by and by disengaged from the envelopes entirely, and elevated on a fine and thread-shaped pedicle, from a line to an inch in length. This elevated globule is the ovary, which when ripe separates into four longitudinal valves, from the extremities of which a number of small, spiral, and elastic threads issue, to which the seeds, or perhaps we should rather say *sporules*, are attached. In *Marchantia* the pedicle, which grows to the height of two or three inches, supports a target-shaped substance, in the under surface of which the ovaries are imbedded. From the above globules, which are the seeds of Hedwig, the species may be propagated;—but it is propagated also by means of other sporules which the frond produces without the machinery of the above apparatus.

HERBS.—Annuals, and plants of a soft texture, are often denominated herbs, to distinguish them from such as are perennial and woody.

HERBARIUM.—No description of a plant is capable of conveying an idea of any species so satisfactory as to leave nothing further to be desired with regard to our notion of its form. The actual inspection of a specimen is indispensable. Hence the necessity imposed upon the student of exploring such districts as are within his reach, or of having resource to the *copia plantarum* of a Botanic Garden. Nor is even this enough. The botanist cannot be always in the field or in the garden, and yet he may want to see his plant, or some important part of it. Hence, also, the utility of dried specimens;—that is, of a *Herbarium* or *Hortus Siccus*.

In the getting up of a Herbarium, the first thing to be done is the selecting of proper specimens. If the plant is small, it may be taken up root, stem, and branch, thus furnishing a whole; and at such a period of its vegetation as shall exhibit leaf, flower, and fruit, both in their nascent and in their mature state. In some cases this may be done by one well-selected specimen, in others it will require two or three specimens. But where the plant is large the collector must be content to take or to procure small portions of it, selected so as to exhibit fairly the character of the species. The specimen, when procured and brought home, is to be neatly and carefully extended on a

leaf of smooth paper, and then placed in the midst of a number of other leaves to absorb all moisture. This process will be accelerated if the whole is put into a press, or under a moderate weight, and the papers changed once or twice a day. It is difficult, under any management, to preserve the colour of the flowers, particularly the blue and the red; or even of the stem of some plants, which is apt to become black, mouldy, and friable, before it is thoroughly dried, as in the case of the Orchideæ. But in both cases quick drying gives the best chance of success.

“When specimens shall have been thoroughly dried, they should be fastened by strong glue, not gum or paste, to half-sheets of good stout white paper; the place where they were found, or person from whom they were obtained, should be written at the foot of each specimen, and the name at the lower right hand corner. The best size for the paper appears, by experience, to be $10\frac{3}{4}$ inches by $16\frac{1}{2}$. Every species of the same genus should be put into a wrapper of a whole sheet, marked at the lower left corner with the generic name. Fruits, if large, may be placed on shelves; if small, in little bottles. To preserve plants against the depredations of insects, it has been recommended to wash each specimen with a solution of corrosive sublimate in camphorated spirits of wine; but I have found that suspending little open paper bags filled with camphor in the inside of the doors of my cabinet, is a far more simple and a most effectual protection. In analyzing dried specimens, the flowers or fruits should always be softened in boiling water. This renders all the parts soft and pliable, and often restores them to their original position.” [Lind. *Introductio*. 465.]

HERMAPHRODITES.—Flowers uniting the sexes,—that is, producing both stamens and pistils in the same individual,—are Hermaphrodite flowers; and plants producing such flowers are Hermaphrodite plants.

HILUM.—This term denotes the mark that is left on the surface of every seed by the natural fracture of the umbilical cord. Linnæus gave it the appellation of the hilum, which the term scar translates. See **DISSECTION OF THE SEED.**

HOOKS.—If the hairs constituting the pubescence of any plant are bent backwards at the point, they are then called hooks.

HONEY.—Honey was at one time believed to be an animal secretion, but naturalists seem now satisfied that it is not. It is the nectar which the bee sips from the flowers of plants, modified by the action of the stomach of the insect. [Kirby and Spence, *iv.* 134.] Yet M. Raspail regards this modification as amounting to nothing. Part of the nectar which the bee sips it actually consumes as its food. The rest it regurgitates, and deposits in its cell unaltered, to be used as

food at a future time. This opinion he founds on the fact that the nectar which the bee sips, and the honey which it deposits in its cells, are scarcely found to differ in any respect whatever. [Nouv. Syst. 307.]

HONEY-DEW.—Honey-dew is a sweet and clammy substance which coagulates on the surface of the leaves of some plants during hot weather, and covers them like a varnish. Mr. Curtis, who wrote a paper on the subject [Lin. Trans. vol. vi.], regarded the substance in question as being merely the excrement of some species of *aphides*, and in this opinion many botanists seem to have concurred. But Sir J. E. Smith, without questioning the accuracy of Mr. Curtis's remarks, contends that the cause thus assigned is not the only cause producing honey-dew. There are cases in which it is undoubtedly an exudation from the plant. The leaves of the Beech-tree are apt to become covered with a sweet and glutinous coating, merely in consequence of an unfavourable wind; which coating we are to regard as being an exudation from the leaf itself, because it is found to be similar in flavour to the fluid obtained from the trunk. [Introd. 189.] It is difficult to conceive how the dropped excrement of aphides should coat a leaf so regularly as leaves are sometimes coated; but if we regard the coating as an exudation, the difficulty vanishes. In the former case the coating may become the cause of disease; in the latter case it may be the consequence of disease. Yet we think there are cases of saccharine exudation that are not at all connected with disease, as will be seen from the examples adduced at the article on the ELABORATION OF THE SAP.

HOROLOGIUM FLORÆ.—We have already shown at the article EXCITABILITY, that light acts as a grand stimulus to the vital energies of the plant, influencing the direction of the stem or branch, the position of the leaf, and the expansion of the flower. This last phenomenon we exemplified in the case of the Lotus of Theophrastus, which he represents as closing its blossom during the darkness of night, and opening it again on the return of the light of day. But of many plants it is not enough merely to say that they open their flowers in the morning, and shut them again in the evening. They have fixed and appointed periods of opening and of shutting; some earlier in the day, and some later, but always at the same hour for the same species; and this succession of periods Linnæus, in his love of metaphor, denominated the *Horologium Floræ*. Flowers requiring but a slight application of stimulus open early in the morning; while others, requiring more, open somewhat later. Some do not open till noon, or till an hour later still; and some, whose extreme delicacy cannot bear the action of light at all, open only at night.

According to Linnæus, the following plants open and shut their flowers as follows. [Phil. Bot. 273.]

<i>Tragopogon luteum</i>	.....	opens at 3 A. M.	and shuts at 9 A. M.
<i>Crepis tectorum</i>	.....	4	..... 10
<i>Sonchus levis</i>	.....	5	..... 11
<i>Sonchus repens</i>	.....	6	..... 12
<i>Lactuca sativa</i>	.....	7	..... 10
<i>Hieracium Pilosella</i>	.....	8	..... 2 P. M.
<i>Calendula arvensis</i>	.....	9	..... 3
<i>Mesembryanthemum neapolitanum</i>	10	.....	3
<i>Ornithogalum umbellatum</i>	[Dec.] ..11	.....	3
Most Mesembryanthemums	.....	12	
<i>Scilla pomeridiana</i>	.....	3 P. M.	
<i>Silene noctiflora</i>	.....	6	
<i>Cereus grandiflorus</i>	.....	7 or 8	
<i>Convolvulus Purpureus</i>	.....	9 or 10.	

The above flowers are said to be *equinoctial*, because they open at a certain fixed hour of the day, and shut at another, and so on, for many days in succession, with a few exceptions; though we do not, after all, see the propriety of the term. But some flowers open only to expand and to fall in the course of one day, or at least to open no more, such as those of *Cistus* and *Linum*, and such are said to be *ephemeral*.

Is light the sole cause of the above phenomena, or is it attributable partly to heat? Decandolle regards it as being attributable to the action of light solely. He observed that flowers opened at the same hour, whether in the open air or in a hot-house. He placed certain flowers under water, and they opened at the same hours as when in the open air. [Phys. Veg. ii. 486.] Yet it has been ascertained that the flowers of plants which are removed from a warmer to a colder climate, expand at a later hour in the latter than in the former. Thus a flower that opens at six o'clock in the morning at Senegal will not open in France or in England till eight or nine, nor in Sweden till ten. A flower that opens at ten o'clock at Senegal will not open in France or in England till noon, or later, and in Sweden not at all; and a flower that does not open at Senegal till noon or later, will not open at all in France or in England. This seems as if heat, or the want of it, were also instrumental in the opening or shutting of flowers; though the opening of such as blow only in the night cannot be attributed either to light or to heat. [Famill. des Plant. i. 104. 1773.] M. Decandolle, by way of a *Postscriptum* to his *Physiologie Vegetale*, puts a number of queries and propounds a number of suggestions, with a view to direct the notice of Phytologists to the investigation of

certain tracts or paths within the scope of botanical enquiry, but which remain, as yet, in a great measure untrodden. Amongst a variety of other questions and suggestions, he has the following—namely:—Is it true that plants transported from a warmer to a colder climate refuse to open their flowers in the latter, or at any rate not till a later hour of the day, as Mr. Keith says?—“*comme le dit M. Keith*”—as if the alleged fact which he seems to have stumbled on, for the first time, in looking into my *System of Physiological Botany*, had been merely the creature of my own fancy. I did not, indeed, give any authority for the fact at the time, because I had not then a copy of Adanson's work before me, as I have at this moment, enabling me to quote both chapter and verse; and now I can but express my surprise that a Botanist so learned as M. Decandolle should have been so little acquainted with the works of a Botanist so celebrated as M. Adanson as not to have been aware of the source of the information.

But the opening and shutting of some flowers depends not so much on the action of the stimulus of light as on the existing state of the atmosphere, and hence their opening and shutting betokens change. If the Siberian Sowthistle shuts at night the ensuing day will be fine; if it opens it will be cloudy and rainy. If the African Marigold continues shut after seven o'clock in the morning, rain is near at hand; and if *Convolvulus arvensis*, or *Anagallis arvensis*, is even already open, it will shut upon the approach of rain—the last of which, from its peculiar susceptibility, has obtained the name of the Poor Man's Weather-glass.

HUMIC ACID, OR HUMIN.—In the morbid exudations that are often occasioned by injuries done to the bark of the Elm-tree, as well as in the bark of many trees even in a sound state, and in the drainings of dung-hills, chemists have discovered what they regard as a peculiar acid, which has been called *Ulmic Acid*, or *Ulmic*. But as it has been found also in vegetable mould, it has been denominated by Sprengel *Humic Acid*, or *Humin*. It is of the class of acids called *Hydrocarbonated*, forming, with alkalies, humates which are readily soluble in water, and hence fit for absorption by the *spongiolæ* of the root. In this way it has been regarded as affording peculiar facilities to the introduction of the alkalies and alkaline earths which are found in plants, and thus performing a very important part in the process of vegetation. Yet it seems doubtful whether we ought to regard it as being a peculiar principle after all, or whether we ought not rather to regard it as being nothing more than the extract or extractive principle of Vauquelin, differing in every plant in consequence of accidental modifications, which seem to be merely modifications of *lignin*. [Raspail Nouv. Syst. 102.]

HYBRIDS.—Hybrids are among plants what mules are among animals,—that is, intermediate productions which have sprung from the sexual intercourse of two individuals of two distinct species. Camerarius seems to have been the first to offer some conjectures on this subject in 1694, when the doctrine of vegetable sexuality was yet new. Bradley proved the fact of the possibility of producing hybrids artificially in 1717; and in 1744 Linnæus wrote a dissertation on the subject, embracing the doctrine and defending it with his usual ability, but without duly scrutinizing his alleged facts; so that, though the doctrine he was endeavouring to establish was true, yet the facts on which he grounded it were all false. Besides, he pushed his generalizations a great deal too far, for he alleged that hybrid productions may occur between species belonging to different genera, and even to different families—a case of which no example that can be at all relied upon has ever yet been met with,—a case that does not occur even in the animal kingdom.

At length Koelreuter took up the investigation of this most intricate subject, and established the doctrine on an induction of facts so full as to leave no room for doubt. The experiments which gave the most decided results were those which he instituted between the several species of *Nicotiana*, as also between the several species of *Digitalis* and of *Hibiscus* respectively. Many other experimenters have instituted similar experiments with a similar success, and from the whole the following laws of hybridism seem to be deducible:—

The species on which you experiment must be nearly related. No one has ever yet succeeded in fertilizing the apple with the pollen of the pear; or the gooseberry, with that of the currant.

Hybrids are fertile only till the third or fourth generation, when they revert ultimately to the type of one of the parents.

The cause of the sterility of hybrids is not well known. They generally produce their stamens and pistils in a state of apparent perfection; though doubtless there is some defect which the eye cannot appreciate.

M. Decandolle says that hybrids resemble the female parent chiefly in the leaf and stem; and the male parent chiefly in the flower and organs of fructification. Dr. Lindley reverses this order; and thus we are left to conclude that the resemblance has been found to be sometimes the one way, and sometimes the other. After all, natural hybrids are but few in number, in proportion to the number of vegetable species; and none, as being the certain production of a union of species belonging to distinct families.

Such are the proofs of hybridism, and the laws to which it is subject. Is it capable of being converted artificially to the use or benefit

of man? The result of the experiments of Mr. Knight furnishes the best reply to this question. Mr. Knight's principal object was that of procuring new and improved varieties of the apple and pear, to supply the place of such as had become diseased and unproductive, by being cultivated beyond the period which nature seems to have assigned to their perfection. But as this was necessarily a work of time, he was induced in the mean while to institute some tentative experiments upon the common Pea, a plant well suited to his purpose, both from its quickness of growth, and from the many varieties in form, size, and colour which it afforded. In 1787 a degenerate sort of pea was growing in his garden which had exhibited no symptoms of improvement even by being removed to a better soil. It was thus a good subject of experiment, and was accordingly experimented upon. First, the male organs of a dozen of its immature blossoms were destroyed, and the female organs left entire. Secondly, when the blossoms had attained their mature state, the pollen of a very large and luxuriant grey Pea was introduced into the one half of them, but not into the other. The pods of both grew equally well, but the seeds of the half that were unimpregnated withered away, without having augmented beyond the size to which they had attained before the blossoms expanded. The seeds of the other half ripened, as in the ordinary cases of impregnation, without exhibiting any conspicuous peculiarity. But when they were made to vegetate in the succeeding spring the effect of the experiment was obvious in the increased luxuriance of the plants. The seeds produced were grey; but by impregnating the flowers of this variety with the pollen of others, the colour was again changed, and new varieties were obtained, superior in every respect to the original on which the experiment was first made. [Phil. Trans. 1789.]

Mr. Knight's experiments were extended also to wheat, but not with equal success. For though some very good varieties were obtained, yet they were found not to be permanent. But his success in experimenting on the Apple-tree, was found, after a due period of expectation, to be equal to his hopes. The plants which were obtained in this case were found to possess the good qualities of both of the varieties employed, uniting the greatest health and luxuriance with the finest and best flavoured fruit. [Phil. Trans. 1799.]

After all, if it be true that hybrids return again to the type of one of the parents in the third or fourth generation, then it will follow that no variety of any annual coming from artificial crossing can ever be rendered permanent. Yet Mr. Knight speaks of his improved variety of pea as being truly a permanent variety; and I suppose it really was so—for, in Kent, there is a permanent variety of pea, known by

the name of Knight's Marrowfat, which the Kentish yeomanry like better without butter, than any other pea with butter, and which I have always hitherto regarded as being the product of some one of Mr. Knight's many experiments; but if it is to give us the slip, after a sowing or two more, there will be but little chance left of our ever falling in with it again; so that the variety may be lost, as were his varieties of wheat. It is not so with a new variety of a woody plant, as the apple or the pear; for if you once get a good variety of either of them, you may multiply it by grafting, and so secure its permanence; but in the case of annuals you have no resource left whatever beyond that of continually crossing the breed. Yet crossings of varieties of the same species are said to be permanent, and this is, perhaps, what Mr. Knight's Marrowfat was.

HYDROGEN.—Hydrogen gas is a permanently elastic fluid, transparent and colourless, but of a very disagreeable smell. It is itself inflammable if in contact with the air of the atmosphere, but it extinguishes burning bodies if wholly immersed in it, and is fatal to animal life if breathed for any length of time. It may be procured by pouring diluted sulphuric acid on iron filings: the gas that escapes is hydrogen. It is the lightest known substance, being fifteen times lighter than atmospheric air, and sixteen times lighter than oxygen. Hence its peculiar fitness for filling air-balloons, a hundred cubic inches of it weighing but a trifle more than two grains.

Under the appellation of phlogiston, or inflammable air, hydrogen was believed by Priestley to be the only true and proper *pabulum* of plants; but this opinion was refuted by the experiments of Saussure. Yet hydrogen, though not inhaled by plants as a food, is still to be found in them; not in a free state to any amount, but as an ingredient in almost all the immediate products of the vegetable analysis. How do plants acquire it? Saussure, with Davy and Decandolle, have shown by various experiments that it comes from the decomposition of water—which article see.

HYGROSCOPICITY.—This term denotes the property by which vegetable tissue, whether dead or alive, tends to absorb or to sip up moisture, so as to put itself in due equilibrium with the surrounding medium.

HYMENIUM.—In the gymnocarpous Fungi the hymenium is the organ that bears the seeds or sporules. In *Helvella* it occurs in the shape of an extended membrane; in the Agarics, in that of gills; and in *Boletus*, in that of pores.

HYPOGYNOUS.—When the stamens originate in the receptacle, and do not adhere either to the ovary or to the petals, they are said to be hypogynous.

IMPERFECT PLANTS.—Imperfect plants are plants defective or apparently defective in one or other of the more conspicuous parts or organs, whether conservative or reproductive, belonging to vegetables in general, such as the root, stem, leaf, blossom. Linnæus characterized them by the appellation of cryptogamous plants, because their organs of fructification are inconspicuous, or are so very minute as to require the aid of the microscope to render them visible. To this circumstance, perhaps, as well as to the apparent insignificance of many of them in the scale of vegetable being, we are to attribute the reluctance with which botanists seem to have entered upon the study of them, and the great obscurity that still envelopes the subject. Not that the subject has been left altogether neglected; but that it presents unusual difficulties, retarding indeed the progress of inquiry, but enhancing the merit of the sedulous enquirer, as in the case of Dillenius, Micheli, Bulliard, and, above all, in that of the illustrious Hedwig—born as it was said to abolish cryptogamy—each of whom acquired his celebrity from the depth or accuracy of his investigations in this most obscure and difficult department of botany, and did much to open up the way to the still more recent enquiries of Fries, Agardh, Greville, Hooker, and other distinguished individuals, who have been thus enabled, by the introduction of new views and new arrangements, to advance and to facilitate, much, the study of cryptogamy. The earlier divisions of this grand group of plants are those by which it was distributed into Filices, Musci, Hepaticæ, Algæ, Fungi—to which several articles we refer the reader for all further detail.

IMPREGNATION.—This term denotes the act by which the vegetable ovulum is rendered prolific through the approach and contact of the pollen. It is equivalent to, or synonymous with, the term fecundation—which see.

INCISIONS.—As incisions are sometimes necessary to the health of the animal, so they are sometimes also necessary to the health of the plant. The trunk of the plum and cherry-tree seldom expands freely till a longitudinal incision has been made in the bark; and hence this operation is often practised by gardeners. If the incision affects the epidermis only, it heals up again without leaving any scar; if it penetrates into the interior of the bark, it does not heal up again but with a scar; but if it penetrates into the wood, the wood itself never heals up completely; but new wood and bark are formed over it as before.

INDEFINITE INFLORESCENCE.—If the principal axis of the inflorescence terminates, always, as it extends, in a leaf-bud, without passing into the condition of a flower-bud, the flower-buds being axillary,—such inflorescence is said to be indefinite; because you cannot foresee where its prolongation is to stop.

INDIGO.—Indigo is a species of colouring matter much used in the art of dyeing. It is the finest of all vegetable blues, and is obtained plentifully from *Indigofera tinctoria*, and *anil*, through means of macerating the leaves and other green parts in water, and leaving them to ferment, at the temperature 27° Reaumur. By and by the water becomes turbid, and there appears a flaky fecula of a white colour, changing by means of agitation and exposure to the atmosphere,—that is, by means of the inhalation of oxygen, first to a yellow, and then to a deep blue. Ultimately it is precipitated in the form of a powdery sediment, which after being made up into small lumps, and dried in the shade, is the Indigo of the shops.

In the above state it is still full of impurities; but in its pure state it is insoluble in water, though slightly soluble in alcohol. Yet its true solvent is sulphuric acid, with which it forms the fine blue dye known by the name of liquid blue. It is composed of 73.26 carbon, 13.81 azote, 10.43 oxygen, and 2.50 hydrogen. [Raspail, 477.]

Indigo may be procured from several other plants besides *Indigofera tinctoria*; particularly from *Isatis tinctoria*, or wood, a native of this country, which antiquarians believe to be the plant with the juice of which the ancient Britons stained their naked bodies to make them look fierce and terrible to their enemies.

INDIVIDUALITY OF PLANTS.—It has been asked whether plants are individuals. But you may just as well ask whether animals are individuals. An animal is an individual composed of a certain complement of distinct organs—the hand, the foot, the eye, the ear, the nostril. A plant is also an individual composed of a certain complement of distinct parts or organs—the root, the stem, the branch, the leaf, the flower. Thus a tree is an individual plant in the sense in which a kingdom or empire is an individual community—that is, one aggregate composed of many members. M. Du Petit Thouars says that the plant is not an individual, because it has no centre of vitality. But why not an individual? It is merely an extension of the embryo which is an individual, and whose centre of vitality is the radicle. Yet buds and branches are by some regarded as individuals, though the plant is not. They are individuals, no doubt; but they are not independent individuals. They are nothing without the support of the primitive caudex. “The branch cannot bear fruit of itself, except it abide in the vine.” But plants that spring from a seed or sporule, or from a bud or bulb, that detaches itself spontaneously from the parent plant, are generally regarded as individuals. Yet some branches, if cut off and planted in the soil, will take root, and absorb nourishment, and grow up as if they had sprung immediately from seeds. What are we to say of them? Theoretically, we may

regard them as being an extension of the old plant, rather than as the generation of a new one; but practically, we are compelled to regard them as being new individuals.

INDUSIUM.—The indusium is a thin and membranaceous integument, covering the groups of capsules peculiar to the Doriferous ferns, and originating for the most part in the nerves or veins of the frond, but sometimes also in the margin. See the article **FERNs**.

INFERIOR CALYX.—A modification of the calyx or flower-cup, including the ovary, but not adhering to it, as in *Primula*. See **CALYX**.

INFLORESCENCE.—The inflorescence, from *florescere*, to flourish, a term introduced by Linnæus, is the peculiar mode of aggregation in which flowers are distributed upon the plant; whence it is also called the mode of flowering.

If the flowers are solitary, they are regarded merely as being cauline, rameal, axillary, or terminal, according to the position of the peduncle or flower-stalk. But when many grow together their aggregation forms a feature in the habit or aspect of the plant peculiarly interesting to the botanist, as forming the most elegant and most invariable of all specific distinctions, as well as being of occasional use in the determining of genera, or of orders. On this account the inflorescence claims our particular notice, and may be regarded as consisting of the several following modes or varieties, resulting from causes which the phytologist cannot fully explain—the head, the whirl, the spike, the panicle, the thyrses, the cluster, the corymb, the fascicle, the umbel, the cyme, the catkin, the spadix,—each of which will be found in its alphabetical position. But there is, also, a more general division of the parts of this subject which botanists now introduce, and which, if well founded, we regard as opening up to our view a new and peculiar law of the vegetable economy, and a new field of investigation, on the ground of the developement of the floral organs;—namely, that of a Centrifugal Inflorescence, and a Centripetal Inflorescence—which see. It involves, besides, an additional distinction; namely, that of a Definite Inflorescence, and an Indefinite Inflorescence—which see also.

INHALATION.—The term inhalation is made use of to denote the act of the introsusception of gases into the plant, in contradistinction to that of absorption, which is made use of to denote the act of the introsusception of liquids into the plant. See **ABSORPTION**.

INSECTS.—Plants are subject to perpetual injuries from the attack of animals, but particularly from that of insects, which feed upon the leaf, or nestle in the bud, or devour the nascent root. See **DEPREDA-TIONS OF ANIMALS**.

INSOLATION.—The exposure of plants to the light of the sun, and the vivifying influence which it exerts upon them, either directly or

in combination with the fluids which they contain, Dutrochet designates by the term *insolation*.

INSTINCT.—There is a variety of phenomena exhibited throughout the extent of the vegetable kingdom, some common to plants in general, and some peculiar to certain species, that has been thought by several botanical writers to be an indication of the existence of a sentient principle in plants, and by consequence of the possibility of vegetable instinct. The tendency of plants to incline their stem, and to turn the upper surface of their leaves, to the light,—the direction which the extreme fibres of the root will often take to reach the best nourishment, as well as the descent of aerial roots, as in *Pandanus*, with the folding up of the flower on the approach of rain, as in *Anagallis*, are phenomena of this description. Not admitting the doctrine of vegetable sensation, but utterly at a loss to account for the singular and hitherto inexplicable fact of the irresistible descent of the radicle and ascent of the plumelet in the process of the germination of the seed, whether on chemical or mechanical principles merely, I thought, in the outset of my phytological enquiries, that it was not absurd to suppose, in the vegetable subject, the existence of a cause analogous to that of instinct in the animal subject, but not identical with it, nor even affinal to it. [Lin. Trans. vol. XI. Pt. ii.] But although the zoologist is allowed the aid of instinct to account for the *unaccountables* of the animal economy, yet the phytologist is not allowed the aid of an analogous principle to account for the *unaccountables* of the vegetable economy. The critics will tell him that the doctrine is “palpably inadmissible;” that “it is absurd;” and that “it is merely a betraying of his ignorance of the cause.” We do not think that this is any great proof of their knowledge. Did Newton know the cause which he points out to our notice by the term gravitation? He knew merely the laws by which a certain principle acts, and he gave it a name: beyond that he knew nothing. The same is the case with the phytologist who talks of a vital principle,—the *vis vitæ*, the *vis formatrix*, and with the phytologist who ascribes the descent of the radicle to a cause analogous to that of animal instinct. He knows very well that he is ignorant of the cause any further than as it produces effects that can result only from the energies of life, and to the energies thus exerted he gives the name of vegetable instinct.

The best and most acute of our phytologists have felt the strong leaning that exists in the human mind to the admission of some such principle. What says Dutrochet, in his *Observations sur la Motilité des Végétaux*? “En voyant cette diversité de moyens employés pour parvenir à une même fin, on serait presque tenté de croire qu’il existe, là, une intelligence secrète qui choisit les moyens les plus con-

venables pour accomplir une action déterminée.” [P. 132.] For myself, I have abandoned the use of the term instinct entirely, as applied to vegetables ; not because the admission of vegetable instinct is a confession of our ignorance of the cause—for it is better to confess our ignorance of a cause than to adduce a false one—but because it is a term calculated to mislead the phytological student, as being so long usurped by the zoologist, and a term, the legitimate use of which seems to me to be that of the denoting of the act of an individual being, regarded as sentient, rather than that of the denoting of the growth of any organ or fabric, whether animal or vegetable. But still I contend for the existence of the thing signified. What I want is a term to convey the idea, that shall be less liable to exception,—a term expressive of vital action resulting from the application of stimuli, but unaccompanied with sensation. The action of the lacteals and intestines of animals is of this description : the former are stimulated by the presence of chyle, and the latter by the pressure of their contents, and are thus excited to action of which the individual knows nothing. We are inclined to think that spontaneity, in default of a better term, might be adopted to express the idea in question.

INTERCELLULAR PASSAGES.—As the great bulk of many plants is composed of a cellular system which the vascular system merely traverses in a longitudinal direction, it will follow that between the cells, which are in their origin of a globular form, certain openings or spaces must necessarily exist. They are denominated by botanists intercellular passages—*meatus intercellulares* ; *méats intercellulaires*. A transverse section of the stem of *Tropæolum majus* exhibits them on a large scale.

But if you take a parcel of oranges, and place upon your table a first stage of six, consisting of three ranks and of two files, all touching, and over that a second stage, and over that a third stage if you please, you will then see, on a very large scale, a similitude of the intercellular passages ; that is, where the cells are globular and the pressure next to nothing. They run equally in a longitudinal and in a horizontal direction, and in the plant are doubtless capable of conducting fluids, whether upwards, or downwards, or horizontally. But as the pressure increases, their capacity diminishes, and in the stem of woody plants their conducting power cannot be very great. M. Decandolle regards them as being the principal channel of the sap's ascent, but in this opinion we do not feel that we can at present acquiesce. See CHANNEL OF THE SAP'S ASCENT.

INTERNAL STRUCTURE.—The internal structure of vegetables is that part of their fabric which is discoverable only by anatomy ; as cells, vessels, fibres, layers, bark, wood, pulp, pith, together with the organs

composing the interior of the fruit and seed, which will be described in their proper places.

INTERNODE.—The space that intervenes between knot and knot, or joint and joint, of stems that are knotted or jointed at regular intervals, is denominated the internode, as in the Grasses.

INTERVENIUM.—The area of parenchyma lying between two or more veins or veinlets of a leaf, is denominated the *intervenium*.

INTEGUMENTS.—Every part or organ of the plant, with the exception of the spongiolæ and apex of the pistil, has its own peculiar integument or envelope. The stem has its bark; the leaf its epidermis; the flower its calyx or corolla, or both; the calyx or corolla their own peculiar cuticle; and the seed its primine and secundine.

INTROSUSCEPTION.—This term denotes the act of taking in, whether of fluids by the root or of gases by the leaf.

INULINE.—The substance denominated *inuline* by Dr. Thomson, as obtainable from *Inula Helenium*, M. Raspail regards as being merely a species of fecula or starch, with which he says it is identical in all its chemical properties, except that its colour is not convertible into blue by the application of the tincture of iodine. [Nouv. Syst. 72.] In this view of the subject M. Decandolle acquiesces: what chemists in general think of it, I know not.

INVERSION OF THE PLANT.—It has been already seen at the article on Germination, that no power or art is capable of converting the radicle into the plumelet, or the plumelet into the radicle. But it is very well known that many plants may be made to grow though inverted, the root being transformed into a stem and branches, and the stem and branches into a root. If the stem of a young Plum or Cherry-tree, but particularly of a Willow, is taken in the autumn, and bent so as that one half of the top may be laid in the earth, one half of the root being taken carefully up at the same time, but sheltered at first from the cold, and then gradually exposed to it, and the remaining part of the top and root subjected to the same treatment in the following year, the branches of the top will become roots, and the ramifications of the root will become branches, protruding leaves, flowers, and fruit in due season.

How is this anomaly to be accounted for? In reply, I would offer the following conjecture. The embryo of the seed is an individual germ, whose developement is necessarily effected in a determinate manner, owing to its peculiar structure or organization. But that happens to be by the descent of the radicle into the earth, and the ascent of the plumelet into the air. It could not, therefore, succeed by being inverted, because the plumelet contains as yet no vegetative principle whose developement could be effected by being placed in the

earth. But this is not the case with the inverted plant, because its leaves or branches contain buds or germs that have been acquired in the process of vegetation; which germs are plants in miniature, containing the rudiments of every thing necessary to the perfection of the species. Consequently they contain a part equivalent to the radicle of the embryo, and capable of being converted into a root when placed in a proper situation. Now the earth affords them that situation, and the inverted plant grows.

INVOLUCRUM.—The involucre or wrapper is a species of Bracte or floral leaf, or an assemblage of floral leaves, peculiar to the tribe of umbelliferous plants, situated at the base either of the general or partial umbel, or at the base of both, and regarded as being a general or partial involucre accordingly. It surrounds the stem or peduncle entirely, as in *Daucus*, or by the one half only, as in *Æthusa*. In the former case it is complete; in the latter dimidiate. If it consists of one leaf, it is monophyllous; if of two leaves, diphyllous; and if of many leaves, polyphyllous. The figure of the leaf or leaves is generally strap-shaped.

Linnaeus regarded it as a species of calyx remote from the flower; but analogy does not justify this view of the subject. A calyx envelopes the flower, but an involucre does not. Linnaeus seems to have thought that the different genera of the Umbelliferae could not be characterized without its aid; and hence, according to his own fundamental and golden rule on the score of genera, he was compelled to regard it as a part of the flower. But modern botanists have found that the seeds of flowers proper of the umbelliferae are sufficient for the purposes of generic discrimination, without the very precarious aid of the involucre. [Smith's Introd. 311.]

IRRIGATION.—It is well known to the farmer or gardener, that his crop will not succeed, unless the soil is seasonably imbued with a due quantity of moisture. He can do a little, it is true, by means of artificial watering, and in some particular cases he may do a good deal. In the neighbourhood of streams and rivers that overflow their banks in the winter, it has been found that the fertility of the soil is restored by preventing the reflux of the water, so as to keep the surface covered with it for several months; and this is what is usually termed *irrigation*, or the artificial watering of meadows.

In this case the amelioration is effected either by the imbibition of part of the water by the soil or subsoil; or by the deposition of the earthy or organic particles or remains with which it may have been impregnated; or by the defending of the roots which are lodged in the soil from the action of frost.

IRRITABILITY.—Plants are susceptible not only to the action of the

natural *stimuli* of light and heat, exciting them gradually to the exercise of their several organs in the regular process of vegetation; they are susceptible also to the action of a variety of accidental or artificial *stimuli*, from the application of which they are found to give indications of being endowed also with a property similar to what we call irritability in animals. This property is well exemplified in the genus *Mimosa*, but particularly in *Mimosa pudica*—more generally known by the name of the Sensitive plant.

If a leaflet of this plant is but touched, however slightly, by any extraneous body, it immediately shrinks into itself, and communicates the impulse, if strong, perhaps to the whole wing, each pair of leaflets collapsing in succession, till they meet on the upper side of the leaf-stalk, and the leaf-stalk itself sinking downwards, as if by a joint, at its point of union with the stem. The following experiments were made by Duhamel with a view to ascertain the extent of its susceptibility, [Phys. des Arb. liv. iv.] At eight o'clock in the morning of a fine day in September, a leaf-stalk of a Sensitive plant formed with the lower part of the stem an angle of 135° , which, upon being touched, fell to an angle of 80° . An hour afterwards it rose again to 135° , and upon being touched a second time it fell again also to 80° . An hour and a half afterwards it rose to 145° , and upon being touched fell to 135° , where it remained till five o'clock in the evening, when upon being touched again it fell to 110° . Hence it follows that the susceptibility is greatest in the morning, or during the heat of the day; but the leaf recovers itself sooner or later, according to the vigour of the plant, the season of the year, and temperature of the atmosphere, as well as the hour of the day at which the experiment is made, though it does not always recover itself in the same way; for sometimes the common foot-stalk recovers first, sometimes the lateral foot-stalk, and sometimes the leaflets themselves.

The leaves of *Dionæa Muscipula*, or Venus' Flytrap, are also extremely susceptible to the action of accidental *stimuli*. They are all radical, and approaching to battledore-shaped, with a sort of circular process at the apex, which is bisected by a midrib, and ciliated with fine hairs like an eye-lash. This circular process is the seat of irritability. For if it is touched with any sharp-pointed instrument, or if an insect but alights upon it, the segments immediately collapse, and adhere so closely, that the insect is generally squeezed to death in its grasp, or at the least detained a prisoner.

A similar susceptibility to the action of accidental *stimuli* has been observed in the leaves of the several British species of *Drosera* or Sun-Dew, of which a very full and satisfactory account is given in the second volume of Withering's "Arrangements," under the head of this genus.

Sometimes the irritability resides in the flower, and has its seat either in the stamens or style. The former case is exemplified in the flower of *Berberis communis*. The stamens, when undisturbed, lie reclined upon the petals which shelter the anthers under their concave tips. But if the inner side of the filament is accidentally or intentionally touched with any fine instrument, or other pointed substance, the stamen immediately bends itself inwards till its anther strikes against the stigma. This fact had been long known to botanists, but it remained to be ascertained whether the susceptibility in question was confined to the inner side of the filament merely, or whether it pervaded the whole stamen. With this object in view, Sir J. E. Smith having procured some flowers fully blown on the 25th of May, 1786, examined them with great care: applying the point of a quill or fine bristle, with all possible delicacy, to every part of the surface of the stamen, he found that it no where exhibited any indications of susceptibility except on the inner side of the filament, towards the base. It had been thought that the stamens possessed this property only at the time of the shedding the pollen. But Sir J. E. Smith found that they possess it at all ages, and even when the petal with its annexed filament has fallen to the ground, gradually recovering their original position, and capable of being again stimulated as before. [Smith's Tracts, 169.]

The stamens of *Cactus Tuna*, or Great Indian Fig, are said to be endowed with a similar irritability. If a quill or feather is drawn across its long and slender filaments, which surround the germen in great numbers, they will immediately begin to bend to the one side, and will by and by sink down to the bottom of the flower.

The latter case, or that in which the seat of irritability is confined to the style, is exemplified in *Stylidium glandulosum*, a native of New Holland. The style of this flower, which is about an inch in length, is bent backwards a little above the base, in the manner of the piece of iron that is fixed to the end of a shepherd's crook, or to the end of the pole of a carriage; so that the style forms a sort of hook with the flower-stalk, the stigma being reflected so as in many cases to touch it. But if the stigma is itself touched with the point of the finger, or other suitable instrument, the style is immediately put into motion, and flies back till it bends itself as much in a contrary direction, and on the other side of the flower, as it did in its first direction. This experiment I had an opportunity of making on a plant in Kew Gardens, on the 31st of May, 1810.

KEEL.—The lower petal of a papilionaceous flower, which is situated opposite to the standard, and hollowed out in the form of a boat, is denominated the Keel.

KELP.—This commodity is obtainable from several species of Sea-weed, but chiefly from the Fuci which grow on rocks and stones on the sea shore, so as to be laid bare at low water. It is of the utmost utility in the important arts of making soap and glass. It is a carbonate of soda, and is prepared as follows. The Fucus or Sea-weed is first cut off close to the rock or substance on which it grows, and well dried in the sun. Pits, or rather beds, are then dug for the purpose of burning it, measuring about three feet in width, eight or ten feet in length, and six or eight inches in depth. A portion of the dried seaweed is now thrown into them, and set on fire; to which additional portions are added in succession, so as that the mass, which they stir up or spread about with an iron fork, may be still kept burning with a smothered flame. Under this treatment the Fucus is ultimately converted into a fluid of the consistence of melted lead, which is collected in the pit till it can hold no more, and then allowed to cool. In the process of cooling, it is condensed into a firm and compact mass of a grey and dusky colour, resembling a lump of solid *lava*. It is now Kelp, and is ready for the market.

KERNEL.—The seed contained within the shell of stone fruit is vulgarly designated by the denomination of the kernel.

KINATE OF LIME.—A salt found in the bark of *Quinquina*.

KNOTS.—The stem of many plants is occasionally disfigured by accidental tumours projecting from the surface, and forming ultimately what are called knots or bunches. They are very common in the oak and elm, and are produced perhaps by means of some obstruction in the channel of the sap's motion, by which the vessels become convoluted and swell up into a lump. Among the branches, knots or bunches are sometimes formed by means of a plexus of young shoots, issuing from nearly the same point, and crossing in all directions, and finally incorporating together in a sort of natural graft, apt to be mistaken at a little distance for a wood-pigeon's nest. They occur often on the branches of the Birch-tree, rarely on the Slow-thorn, and are known among the peasantry of Scotland by the name of Witches' Knots. They are occasioned, doubtless, like the bunches of the stem, by some obstruction in the channel of the juices of the plant.

LABDANUM.—This substance, which is called also *ladanum*, is a resin obtained from *Cistus creticus*, a shrub which grows in Candia and other Grecian Islands. The surface of the leaves is covered with a viscid juice, which is collected by means of a sort of rake furnished with thongs of leather, to which the juice adheres. It is afterwards scraped from the thongs with a knife [Tourn. Voyage du Levant.] It is very soft and always mixed with sand and dust. Its colour is

blackish, its odour fragrant, and its taste bitter. When dissolved in alcohol it leaves behind it a little gum. It is employed in making plasters.

LABIATÆ.—A term first introduced by Tournefort to designate his class of plants with lipped flowers; and adopted by Jussieu to designate one of his orders. It seems to be equal in extent to the *Verticillatæ* of Linnæus—flowers in a whirl with two gaping lips.

LAC.—This substance was long regarded as the produce of *Croton lacciferum*, and a few other plants indigenous to India, being described as a resinous exudation of the leaf, occasioned by the puncture of *Coccus lacca*. But Messrs. Kirby and Spence represent it as being entirely the produce of the insect itself, and not an exudation in consequence of its puncture. It forms the basis of many varnishes, and of the finest kinds of sealing-wax.

LATEX.—The latex, according to M. Schultz, to whom we are indebted for the introduction of the term, is the proper juice or vital fluid of the plant, secreted from the crude sap in the intercellular passages, and is thus, in its formation, analogous to the formation of blood in animals. It is contained in delicate, transparent, membranous tubes, intercommunicating by lateral branches, and occurring both in the woody fibre and bark, which they ascend till they reach the leaves, whence they again descend till they reach the extremities of the root. The contained fluid is said to exhibit evidence of its being in motion, in distinct, but partial and irregular currents, some up, some down, some to the right, and some to the left, suddenly stopping, and then suddenly recommencing, but not exhibiting any very close analogy to the circulation of the blood of animals. [Lardner's *Cyclop.* vol. xxv.] After all, the *Latex* of Schultz seems to us to be nothing more than the *Cambium* of Duhamel under a new name, and it is well known that the anastomosing of vessels conducting fluids is not a new doctrine. Look at them in the leaf.

LAURINE.—A substance discovered by Bonastre in the berries of *Laurus nobilis*, which Decandolle regards as belonging to the class of the *resinoides*. [Phys. Veg. i. 355.]

LATERAL COMMUNICATION.—The doctrine of the direct ascent of the sap through the channel of the longitudinal vessels, seems never to have been clogged with any doubt. But doubts had, at one time, arisen about what has been called lateral communication. Do the vessels conducting the sap communicate with one another by inosculation or otherwise, so as that a portion of their contents may be conveyed in a lateral direction, and consequently to any part of the plant; or, do they form distinct channels throughout the whole of their extent, having no sort of communication with any other set of vessels, or with one another?

Each of the two opinions implied in the question, had its advocates and defenders. At the head of those embracing the former, we find Malpighi; at the head of those embracing the latter, we find Grew. Malpighi maintained that the vessels inosculate, and are hence capable of conveying the sap in all directions. Grew maintained that the vessels do not inosculate, and are hence not capable of conveying the sap in all directions, but destined merely to the nourishment of a particular part; alleging as his proof, that if a tree having two or more principal branches, with the same number of principal roots, has one of the roots cut off, the branch corresponding to it will be considerably affected by the loss. But if it is not absolutely killed by it, a lateral communication must exist, which the following experiment demonstrates. Hales having selected two branches of equal size, made four incisions into one of them, answering to the four cardinal points and each penetrating to the centre; in the other he made no incision. He then put the extremities of both into water, and found that the branch which was cut with incisions absorbed moisture as copiously as the one which was not so cut. Duhamel and Knight had similar results from similar experiments; from all which it follows that the sap, though flowing the most copiously in the direct line of ascent, is at the same time also diffused in a lateral direction. It should besides be recollected that plants are furnished with a cellular tissue as well as with a tubular tissue, which seems well calculated for the conducting of sap in any direction whatever. Mirbel, to secure a lateral communication of sap, furnished both his vessels and his cells with visible pores. The German Doctors could not find his pores, and may be said to have demolished his theory. But still the fact of a lateral communication of sap remains unshaken, and the practicability of the process is demonstrated upon the principle of the theory of Dutrochet, who ascribes it to the agency of molecular infiltration;—a power fully adequate to the production of the effect in question.

LATITUDE.—Latitude, in its relation to vegetables, may be regarded as being very nearly synonymous with climate. Latitudes approaching the equator are the hottest; latitudes approaching the poles are the coldest. Yet the same parallel of latitude is not always of the same temperature in all longitudes. See **CLIMATE**.

LEAF.—The leaf, which belongs to the division of the temporary parts of the plant, is a thin and flat substance, of a green colour, issuing generally from the extremity of the branches, but sometimes also immediately from the stem or root, and distinguishable by the sight or touch into an upper and under surface, a base and an apex, with a midrib and lateral nerves. Yet leaves are not always thin and flat, nor are they always green. The leaves of the Aloe are thick and

fleshy; and the leaves of the several species of Beet-root are of a deep and dull purple. Neither are they always furnished with transverse or lateral nerves. Such are proper to Dicotyledonous plants only, for in Monocotyledonous plants the nerves are all parallel. The point by which the leaf is attached to the plant is the base; the opposite and terminating point is the apex; the intermediate body of the leaf is the expansion; and the boundary of the leaf is the margin.

The figure of the leaf, or expansion, has been found to be of great use to botanists in the discriminating of the several species of a genus; and hence they have spared no pains to determine, by observation and description, its varieties of form. Linnæus enumerates more than a hundred. [Phil. Bot. sec. 83.] If the expansion is flat and membranaceous, the most frequent forms are the circular, the oval, the oblong, the triangular; if thick and succulent, the most frequent forms are the cylindrical, the semi-cylindrical, the sword-shaped, the compressed. The apex is acute, or obtuse, or bitten, or truncated, as in the leaves of the Tulip-tree. The margin is entire, or notched, or toothed, or serrated. The expansion is entire, or cleft, or lobed; yet the figure of some leaves is altogether anomalous, and cannot be brought under any of the foregoing divisions. The leaf of *Nepenthes distillatoria*, which is itself lanceolate, terminates at the summit in a sort of thread-shaped pedicle, supporting a hollow and cylindrical, or rather pitcher-shaped appendage, to which there is attached the curious and peculiar process of a lid opening at one side. This appendage secretes a fluid which is said to be very pleasant to the taste. The leaf of *Dionæa Muscipula*, which we have just had occasion to describe, affords a good and additional example of the anomalies of form that occur in this organ.

In their size, leaves exhibit as much variety as in their figure. But it is not always the largest plant that has the largest leaf. The leaf of *Caltha palustris*, though a humble herb, is larger than the leaf of the oak, though a lofty tree. The largest leaf produced by any British plant is, as I believe, that of *Arctium Lappa*, or of *Tussilago Petasites*, which is often to be met with of the dimensions of upwards of twenty inches in length by eighteen at the greatest breadth. The leaves of *Strelitzia Reginæ* grow to a length of three or four feet, with a breadth of eighteen or twenty inches at widest. The leaves of the Plantain-tree, *Musa Paradisaica*, has been known to grow to the extent of ten feet in length by two feet at the base [Lour. Flor. Cōchin]; so that, owing perhaps to their extraordinary dimensions, some writers have supposed them to be the leaves of which Adam and Eve are said to have made themselves aprons when they first felt

the want of clothing. [Gen. iii. 7.] But the largest of all simple leaves is doubtless that of the Talipot-tree of Ceylon, *Corypha umbraculifera*, said to be often met with of such a magnitude as to measure not less than eleven feet from the base to the apex, by sixteen feet across at the widest part; giving thus an ample circumference of nearly forty feet, and forming when fully expanded a most capacious and efficient parasol.

The leaves of trees, from their size or number, are naturally calculated to form an agreeable and cooling shade amidst the sultry heats of the intra-tropical regions :

“Where broad Palmettos shower
Delicious coolness in the shadowy bower.”

MONTGOM. WEST INDIES.

And even in countries that are not intra-tropical, the shade afforded by the leaves of trees is still extremely desirable during the heats of summer. Hence the soft and balmy slumbers which an ancient poet experienced under the cool and delightful shade of the Plane-tree :

Αὐταρ ἐμοὶ γλυκὸς ὕπνος ὑπὸ πλατάνῳ βαθυφύλλῳ.

MOSCH., IDYLL. V.

Hence also the celebrity of the groves of Academus, where Plato and his successors delivered their lectures on philosophy, and instilled into the minds of their youthful followers the love of truth.

“Scilicet ut possem curvo dignoscere rectum,
Atque inter sylvas Academi quærere verum.”

HOR. EPIST. II. Lib. ii. 44.

The odour of many plants, which is extremely grateful to the smell, as well as their virtues, whether medical or dietetical, is very frequently contained in the leaf. Lastly, as the leaf is merely a temporary or deciduous part, it dies in the autumn or winter, and is regenerated in the succeeding spring, exhibiting an apt and edifying emblem of the succession of human generations, according to the beautiful remark of the greatest of all poets :—

Οἷη περ φύλλων γενεή, τοίηδε, καὶ ἀνδρῶν
Φύλλα τὰ μὲν τ' ἄνεμος χαμάδις χέει ἄλλα δὲ θ' ὕλη
Τηλεθόωσα φύει, ἔαρος δ' ἐπιγίγνεται ὥρη·
“Ὡς ἀνδρῶν γενεή, ἣ μὲν φύει, ἣ δ' ἀπολήγει.

HOMER. ILIAD, vi. 146.

—“As it is with the race of leaves, it is with the race of men. The cold wind blows and scatters the leaves on the ground; but the grove budding again, protrudes a new progeny, which is matured in the succeeding spring. So it is also with men : one generation perishes, and

another springs up in its room." While it exists, however, the leaf forms one of the principal ornaments of the plant, clothing it with verdure, and covering it with grace; and even in its decay and fall it ceases not to gratify the eye; assuming by slow degrees a paler and milder shade, and tinging the forest and the plain with an infinite variety of hues. The functions of leaves, as exercised in the economy of vegetation, will be found to have been introduced under the head of the articles, **ELABORATION OF THE SAP**;—**ELABORATION OF OXYGEN**;—**ELABORATION OF CARBONIC ACID**.

LEAF-STALK.—It often happens that the base of the leaf is prolonged into a sort of semi-cylindrical pedicle, by which the expansion is removed to some distance from the point of attachment to the stem or branch, as in the Vine and Poplar. This pedicle is denominated the foot-stalk or petiole, entering the expansion generally by the margin, but sometimes also by the centre, as in *Nasturtium*. In *Populus tremula*, it is compressed in a line at right angles to the expansion, which peculiarity M. Du Petit Thouars regarded as the cause of the leaf's mobility. [Cours de Phyt. seau i. 24.]

LEGUME.—The legume is a dry and elongated pericarp or fruit, consisting of two valves with two opposite seams, to the one of which the seeds are attached, as in the pea or bean. It consists for the most part of one cell only; sometimes of two, as in *Astragalus*; and sometimes of many, as in *Lotus*. It is one-seeded, or two-seeded, or many-seeded, as in *Pisum*. Its figure is oblong, as in *Ulex*; or cylindrical, as in *Orobus*; or rhomboidal, as in *Ononis*. Its substance is membranaceous, as in *Medicago*; or leathery, as in *Vicia*; and the surface smooth, as in *Lathyrus Nessolia*; or rough, as in *Lathyrus hirsutus*.

LEPALS.—The sterile stamens which occur in many flowers, originating in the same whirl, or between the true stamens and the pistil, assuming the form of glands, or of petaloid scales, botanists designate by the term *lepal*.

LIBER.—The innermost layer of the bark is denominated the liber, —the Latin name for a book, from the circumstance of its having been sometimes used by the ancients to write on, before the invention of paper. It is the finest and most delicate of all the layers of bark, and is often most beautifully reticulated. See *Cortical Layers*, under the head of **CONCENTRIC LAYERS**.

LICHENS.—In the arrangements of Linnæus and his earlier disciples, the Lichens were introduced as a grand division of the order Algæ, to which, it must be confessed, their affinity seemed to be but very slight. Modern botanists have now erected them into a distinct order of the class Cryptogamia, to which elevation they seem to be well entitled, both from their general appearance and texture, as well as from the great extent of the order itself. [See Hooker's British Flora.]

LID.—When the calyptra of the Mosses has fallen, the mouth of the capsule is still found to be covered with a lid, terminating in a beak or rostrum, usually called the *operculum*.

LIFE WITH ITS CONDITIONS.—What is life? The great variety of definitions by which physiologists have attempted to exhibit an idea of life shows that it is no easy task to do so correctly. The subtle and untangible character of the subject to be defined is, doubtless, the grand cause of the difficulty. Bichât, a French physiologist of great celebrity, defined it as follows:—"La vie est l'ensemble des fonctions qui résistent à la mort" [Recher. Phys.]—"Life is the totality of the functions that resist death." It is a trait from the pencil of a great master, but it is by much too indefinite to exhibit a distinct view of the subject. Functions seem to be rather the result of life than to be life itself; but what is the amount of their resistance, for death finally overcomes them; and of what class of bodies are they predicable? Richerand defined it thus:—"La vie est une collection de phénomènes qui se succèdent pendant un temps limité dans les corps organisés" [Traité de Phys.]—"Life is a collection of phenomena that occur during a limited period in organized structures. But the boundaries of this limited period are undefined, and must consequently be supplied by the imagination of the reader. They may include even the phenomena of death for any thing that the definition shows to the contrary. Mr. Lawrence does not profess to give a formal definition, but he gives us what is equivalent to one. It is very brief, and is as follows:—"Life is the active state of the animal structure." [On Physiology.] This evidently excludes the torpid state. It excludes also vegetables, which it might indeed be made to embrace, by the insertion of a single word; but if life may exist even in a state of rest, surely it cannot be well defined merely by calling it a state of action. A writer who regards the above definitions as savouring too much of materialism, not to say atheism, gives us another definition, the briefest of all:—"Life is inherent activity." [Remarks on Scepticism.] This, it must be acknowledged, is rather too scanty; but it is abundantly comprehensive; for it includes every thing of which inherent activity can be predicated, be it mind, or be it matter. Yet it is going a great deal further than its author intended, seeing that it is an approach to the materialism of which he accuses others. There is an inherent activity in the movements of the *Aurora borealis*, the merry dancers of the north; but it is not life. There is an inherent activity in the vivid coruscations that dart across the sky, and illuminate the loaded atmosphere, in a night of electrical tempest; but it is not life. There is an inherent activity in the cause that occasions the eruption of a burning mountain—that subterranean

artillery which melts the solid and primeval rocks, and upheaves them in floods of liquid lava; but it is not life. Hence inherent activity is not the criterion of life. On the contrary, this activity is possessed by many bodies that we cannot at all regard as being living substances. What are chemical, magnetical, or electrical attractions and repulsions, if they are not examples of inherent activity?

It would be presumption in me to attempt to do that which the above distinguished physiologists, or their more orthodox criticsers, have failed to do,—namely, to exhibit a correct idea of life by the selection of a single trait. But as their failure seems to be attributable chiefly to an unnecessary effort at brevity,—

“Brevis esse laboro,
Obscurus fio,” HOR. DE ART. POET. 25.

perhaps it might be worth our while to try the effect of a fuller enumeration of particulars. What we lose in point and neatness, we may gain in perspicuity; and upon this principle I submit the definition that follows:—Life is that energy, or attribute, of organized structures which renders them capable of receiving and of obeying the impulse of *stimuli*. It is real, or it is potential; real, if the susceptibilities are in operation, as in the case of an animal in motion, or of a plant protruding its buds or blossoms; potential, if the susceptibilities are dormant, as in the case of an egg not hatched, or of a seed not sown; or as in the case of the hybernation whether of plants or animals. Life originates in precedent life, and terminates in subsequent death, which is an extinction of all vital functions, and of all possibility of vital functions. Taking this definition with its illustration as our text, we proceed to remark that life, in the exhibition of its phenomena, always presupposes the existence of certain peculiar conditions, previous, or concomitant, or consequent, without which it has never been known to manifest itself, and of which the most essential are the following:—parentage, organization, aliment, aeration, temperature, death.

I. *Parentage*.—There was a time in which philosophers believed in what was called the doctrine of equivocal generation—that is, generation springing from a fortuitous concourse of atoms having an appetency to combine themselves into living forms. This doctrine was taught and maintained by the most celebrated philosophers of antiquity. Plants were regarded by Diogenes as being generated from a mixture of earth and putrid water; the water acting upon the earth, and moulding it into form. Plants whose seeds are not apparent were regarded by Theophrastus as being propagated by spontaneous generation, because some tribes of animals were thought to be so propagated [*Πεφί Φυτῶν* Ιστ. I.]; and parasitical plants were

regarded as springing from some corrupted matter generated on the tree producing them. [Ibid. v.] The poets of antiquity had the same fictions. Ovid replenishes his post-diluvian world with animals that sprang up out of the earth *sponte sua*, excited by heat and moisture. [Metamor. lib. i.]

The philosophy of the dark ages was not likely to correct the errors of antiquity, and when a better philosophy was introduced at the time of the revival of learning, it could not be expected to correct them all at once. Even Bacon, the great reformer of philosophical methods, still gave his sanction to the doctrine of equivocal generation, as may be seen by perusing his *Sylva Sylvarum*. The mosses that grow on trees he regards as being nothing more than a sort of excretion which the tree cannot assimilate; and the Mistletoe he represents as being produced, not from seed, but merely from a superabundance of nourishment. But the truth of the doctrine began to be at last suspected, and subjected to the test of observation and experiment. It was a scrutiny which it could not stand, and beneath which it fell refuted. The credit of the refutation is due partly to Harvey, who contended that all animals spring from eggs deposited by a parent—*omne animal ex ovo*—and partly to Francisco Redi, an Italian philosopher and physician, whose experiments are well known to the zoologist, together with their result,—namely, that there is no such thing as a generation of insects from putrefaction. Similar investigations were applied to the vegetable kingdom by Malpighi and others with similar results, demonstrating that all plants spring from seed the produce of a parent—*omnis planta e semine*. In short, the doctrine of equivocal generation came into universal disrepute; and the stories of showers of frogs that fell from the clouds, and of armies of insects engendered by the east wind and wafted on its wings, together with the marvellous account of a Plane-tree that sprang up spontaneously from a brazen tripod, as related by Theophrastus, were no longer credited.

Such was the triumph of truth over error. Yet the very progress of the science that achieved it gave rise to new doubts. In the advance of microscopical discovery, a new world was laid open to the view of man,—namely, that of the *animalcula infusoria*, and others. The most successful of the earlier operators in this department of science were Leuwenhoeck, Needham, Swammerdam. Leuwenhoeck estimated the size of the smallest of the animalcules, and found that upwards of 1,000,000 of them might be contained in a space not larger than that occupied by a grain of coarse sand. [Phil. Trans. Abridged, vol. ii. 377, and vol. iii. 203.]

Concerning their origin every philosopher had his own opinion. Some regarded them as being generated by parents of the species, rather from analogy than from any direct proof, which in objects so minute it must be next to impossible to obtain. Buffon regarded them as being, not the produce of generation, not germs or embryos, not either animals or vegetables, but merely organic and moving particles proper to compose a living being. If this were really the case, the species or varieties of animalcula would be interminable, as there would be no end to new combinations of organic particles, and no certainty of finding to-morrow the species you have met with to-day. But the contrary of all this is the fact. The species are not interminable, but circumscribed, and in some of them the mode of propagation has been actually ascertained. But animalcules have been found in infusions, or in other materials that were boiled, roasted, and even subjected to the heat of a blow-pipe; and this has been regarded as a proof that they could not have proceeded from any thing possessing life. Yet the vitality of some seeds is known to survive even the action of boiling [Spallanzani], and we are entitled to suppose that the seminal germs of animals are at least equally vivacious. Besides, if the infusion in question were deprived of every thing vital, whence came the animalcules? They must have come from without. They must have penetrated the containing vessels—a fact which cannot be admitted without due evidence.

Fray affirms that he found animalcula in mineral mixtures [Essai sur l'Orig. des Corps Organ.]; and a doctrine approaching to this has been advanced by Dr. Robert Brown, who finds active molecules, which he does not indeed elevate to the rank of animalcules, in rock, glass, ashes, soot, when ground to an impalpable powder and mixed with a little water. But as this question may be said to be as yet *sub judice*, we will adopt the proposition of Cuvier, and say with him, "*La vie ne naît que de la vie*"—Life originates only in life. [Leçons d'Anat. Compar.]

This proposition has been a good deal carped at, unfairly, as we think, by Barclay, who disapproves of the doctrine which it contains altogether, and asks whether the first individual, or the first pair of any species, could have come into existence in this manner? The reply is ready. Cuvier's object was not that of tracing phenomena to their first causes, which may be concealed for ever from human view, but merely to such causes as fall within the sphere of human observation, and are cognizable by human means. This is philosophy; this is physiology. The study of a first cause is religion, and our knowledge of it is derived chiefly from revelation. We do not say that it must necessarily be excluded from physiological research, but

if the individual inquirer chooses to exclude it for the purpose of keeping separate two subjects that are perfectly distinct, he is not therefore to be regarded as an atheist. What light has Dr. Ure thrown on geology by his boasted introduction of the agency of a first cause? No light whatever. "But," says Barclay, "what are we to make of the *animalcula infusoria*? It has not been proved that they are the product of generation, and yet they are evidently endowed with life." [On Life and Organization.] To this we will reply by the following question:—Has it been proved that they are not the product of generation? If the higher orders of animals,—the animals with which we are best acquainted,—are evidently the product of generation, ought we not to conclude from analogy that other and inferior orders of animals, with which we are less acquainted, are the product of generation also? On this account we rest satisfied of the legitimacy of the conclusion of Cuvier.

II. *Organization*.—A very general and very good division of the bodies existing in nature is that by which they are distributed into the two primary classes of unorganized and organized productions.

Class First—*Unorganized productions*.—If we suppose a gradation by which all natural bodies are placed according to their rank in the scale of being, the unorganized substances will be found at the bottom. They exhibit no indications of life, no susceptibility to impressions, no sympathy of parts, no functions. Still they possess a definite number of properties, physical or chemical, by which they are readily characterized,—gravity, elasticity, mobility, affinities, attractions, repulsions. They display also a gradation among themselves. Some of them are found merely in shapeless lumps, that accident seems to have thrown together, and that accident may again disperse,—masses of rock, masses of minerals. Others are found to present themselves in regular and symmetrical forms, whether individually or in the aggregate,—crystals, masses of crystals. If we regard the fabric of the earth which we inhabit, we find that it is moulded into an immense and globular mass; but is destitute of all organization, as are the fluids with which it is watered, and the gases with which it is surrounded. The same remark may be extended, as we presume, to the heavenly bodies also,—the sun, the stars, the planets, and their satellites.

Class Second—*Organized productions*.—Organized bodies stand higher in the scale of being than unorganized bodies, and are endowed with nobler properties. They are the sole receptacles of life, which has never yet displayed itself except in such fabrics. They consist in

their living state partly of solids, and partly of fluids in motion. The fluids are the materials out of which the solids have been formed,—chyle, blood—sap, proper-juice ; or they are secretions or exhalations, or excrements coming from the solids,—bile, urine, perspirable matter,—gum, nectar, perspirable matter. In the aggregate they form a fabric which is composed of a definite system of individual fabrics or organs, which constitute in their assemblage an individual whole,—a plant, an animal. An organ is a fabric adapted by its structure to the performance of a function,—a hand, a foot, a leaf,—prehension, progression, aeration. Bichât has remarked that the organs destined to the higher functions of the higher orders of animals,—the organs by which they communicate with the external world,—are more symmetrical in their forms than other organs, and many of them double, as the eyes, the ears, the hands, the feet ; or divisible into two corresponding halves, with a manifest medial line, as the brain, the tongue. The higher the function, the greater the symmetry of the organ. We may extend this remark to vegetables also. It will not be found to apply so generally, nor in the same degree ; but it is easy to discern traces of the fact. The leaves and petals are among the most important of all vegetable organs, and they show this peculiarity very conspicuously. They are divisible into an anterior and posterior surface, and into a right and left side, separated by the intervention of a midrib. The interior organs of the flower may be regarded as divisible into two equal and similar halves ; the anthers particularly are so divisible ; and perhaps the beautifully twisted form of the spiral threads should be regarded also as an example of the symmetry in question.

An assemblage of several organs, all concurring to the production of a single result, constitutes an apparatus,—the visual apparatus, the digestive apparatus, the lacteal apparatus,—the absorbing, the inhaling, and the exhaling apparatus. An assemblage of organs possessing the same or a similar structure constitutes a system,—the vascular system, the osseous system, the nervous system. The immediate constituents of organs are tissues,—the cellular tissue and the fibrous tissue.

1. Of all living bodies, whether plants or animals, the principal mass is composed of the cellular tissue. It enters into the composition of almost every organ whatever, and binds and cements together the fibres that pervade it. Particularly, it forms the principal mass of succulent plants, and a notable portion of many parts of woody plants. It abounds in succulent fruits, and in the lobes of all seeds. It consists of clusters of little cells, or vesicles containing an inclosed fluid, which Grew compared in their aggregate aspect to the bubbles

formed upon the surface of liquor in a state of fermentation. The *fœtus* seems a homogeneous mass of cellular tissue filled with a gelatinous fluid. As the organs begin to show themselves, this mass becomes more condensed; and as the bulk of the organs increases, the proportional bulk of the tissue diminishes. It is the receptacle of lymph, and of fat, and is, at all periods of life, that on which depends the plumpness or *embonpoint* of the individual.

2. Of all living bodies, whether plants or animals, a notable portion is composed of the fibrous tissue. The fibres are very often arranged in groups or bundles passing longitudinally throughout the whole extent of the organ, as in the stipe of *Aspidium Filix-mas*, or in the leaf-stalk and leaf of the Elder; or they are distributed in thin plates, as in the net-work of the layers both of the wood and bark. When viewed superficially, they appear to be merely individuals; but when inspected minutely, and under a good glass, they prove to be groups or bundles made up of fibres smaller and minuter still, firmly cemented together, and forming in the aggregate a strong thread, but capable of being split into a number of component fibriles, till at last you can divide them no longer. In animals, they are found in bundles, in the muscles, tendons, and ligaments; but in the *periostium* and *sclerotica* they are found in plates. [Bichât. Anat. Gen. ii. 251.]

Every organ is united to the organs adjoining it by peculiar and appropriate bonds, and is invested, and, if admitting it, lined with an envelope of fibrous or of cellular tissue; and every living individual is enveloped with a covering of bark, or of skin, or of shell, or, at the least, with a fine epidermis. If the tissues are themselves examined with a view to ascertain the elements of their own composition, they will be found to consist of fine films or fibriles, which seem to be themselves composed of multitudes of minute and gelatinous molecules closely compacted together, and distinguishable only by the microscope. Their diameter is represented as not exceeding the $\frac{1}{8000}$ part of an inch; but their existence is by some doubted. Beyond this, the analysis of the dissector cannot go. Here, his anatomy ends.—If he proceeds to chemical analysis, he will find that the proximate principles of the animal solids are chiefly albumen, fibrine, gelatine; the remote principles being azote, oxygen, hydrogen, carbon, with the azote predominating. [Magendie.] Of the vegetable solids, he will find that the proximate principles are chiefly gum, sugar, starch, gluten, albumen, fibrine, extract; the remote principles being carbon, hydrogen, oxygen, with the carbon predominating. [Davy's Agri. Lect.]

When the proximate principles of animals—albumen, fibrine, gelatine—are converted, artificially, from a fluid to a solid state, as by the

action of heat, or of other chemical agents, multitudes of minute globules, similar to those of the blood, are said to be developed in the mass. [Edwards sur La Vie.] It is a presumption in favour of the globulous structure of ultimate living tissue.

It has been asked whether the vital powers reside in the fluids, or in the solids, or in both. Some physiologists would confine them to the solids. But Mr. J. Hunter extended the attribute of vitality to the fluids also; or at the least to the blood of animals. Blumenbach could see no ground for adopting this opinion. If you grant vitality to the blood, because it is the material from which the living solids are produced, as well, says he, may you grant it to water, because the Nymphææ and many other plants are nourished by it. We do not think that the case is fairly put. Blood is an elaborated fluid fit for immediate assimilation or nutrition; and the vegetable fluid corresponding to it is not water, but *Cambium*. Bichât admits that the fluids begin to acquire animalization and vital properties in the course of their elaboration in the system. The chyle is more animalized than the alimentary mass,—and the blood more animalized than the chyle. [Anat. Generale.] But this is enough to sanction the vitality of some fluids, and the vitality of all fluids is not contended for.

The fluids of the human body are represented by Bichât as being to the solids in the ratio of nine to one; and the fluids of vegetables as being in a greater ratio still. They are viscous, and transparent, or coloured. Many of them seem to contain globules of a regular figure and magnitude, particularly in the blood, lymph, and chyle. In a drop of the spermatic fluid, the microscope discovers hundreds of thousands of little animalcules. The same remote and proximate principles are found both in the fluids and solids of animals and of vegetables respectively; and are reduced by evaporation to semi-solids, exhaling carbonic acid, and absorbing oxygen from the atmosphere, as well as exhibiting, in their composition, millions of minute globules.

III. *Aliment*.—All substances capable of affording nourishment to living beings are aliments; and no living being can subsist any great length of time without the use of them; whatever may have been said or believed to the contrary. If a plant is deprived of the access of moisture, it languishes, and withers, and dies. If an animal is deprived, for a length of time, of all nourishment, a feeling of pain is excited in the region of the stomach, followed by faintness and loss of strength, which, without new supplies of food, would ultimately and inevitably terminate in death. As plants cannot range the fields in quest of nutriment, it was necessary that some provision should be made to furnish them with due aliment, without any effort of their own. Accordingly, the Creator has provided that they shall find their food in

the soil in which they grow. Thus, their food is already digested, and they take it up through means of the *spongiolæ* of the root, by the slow and protracted process of absorption. But though the food of plants consists chiefly in the alimentary ingredients which they find in the moisture of the soil, yet we have reason to believe that they derive part of their food from the atmosphere also. The leaves attract and absorb its moisture. They inhale also its gases through means of their *stomata*; and there are plants that live and thrive without any other food. *Epidendron Flos-aeris* may be quoted as an example.

With regard to animals, however, which are not circumstanced so as that their food shall spontaneously approach them in a digested state, and not able, after all, to exist without food for any great length of time; some means of stimulating the individual to the finding and taking of a due and regular supply of food became indispensable. This we find to have been provided for most effectually, in the sensations of hunger and of thirst that are excited irresistibly in the stomach or *fauces* when a new supply of food or of drink is wanted, urging us to the pursuit and assumption of aliment; as well from the pleasure which the gratification of appetite promises, as from the pain which the sensation of hunger or of thirst causes.

Most animals select, as aliment, both solids and fluids, though many of the lower tribes select fluids only. Yet solids are not available for the purpose of nutrition till they have been reduced to fluids. Hence animals selecting solids are furnished with organs calculated to effect this process, which plants and the lower tribes of animals do not stand in need of,—namely, a mouth and an alimentary canal. The aliment of animals in general consists of herbs, fruits, or flesh; but the food which individual animals select varies according to the species. Some animals are granivorous, as many birds; some are graminivorous, as the sheep and ox; others are carnivorous, as the lion and the tiger. Man eats almost any thing, and drinks almost any thing; but he likes to have his victuals cooked. Most animals gather their food with the mouth directly; as the horse, the cow, the sheep, the goat; yet some have peculiar organs of prehension, with which they first seize their food, and then convey it to the mouth. The Medusæ have lashes or *tentacula*; the elephant has a *proboscis*; men and monkeys have hands.

It has been thought that a line might be drawn dividing the animal from the vegetable kingdom upon the ground of the character of the food affected by each. Plants feed, it is said, upon unorganized substances,—earth, salts, water, gases; animals, upon substances already organized,—that is, either upon other animals, or upon vege-

tables. We do not regard it as a very good or a very correct rule. Animals thrive well upon milk alone, which is not an organized substance; and although they feed, for the most part, upon substances that are still in an organized state, yet they cannot convert them into nourishment till they have destroyed their organization in the stomach.

A better criterion for distinguishing the animal from the plant, will be found in the attribute of sensation; for, though there may be some phenomena that give countenance to the idea of vegetable sensibility, yet they are not such as the physiologist can confidently rely upon; and as the attribute of sensation distinguishes the animal from the plant, so their assumption, and their assimilation of aliment, and their origin and mode of growth, will distinguish them both from the mineral. We are aware that some of the German Doctors, in their transcendental flights, among whom we may place Carus, have not hesitated to ascribe, even to unorganized substances, the attribute of life;—to crystallizations, as we believe, and to the earth that we inhabit, as well as to the heavenly bodies also. Yet this we regard as an abuse of the term life, as we confess we can see nothing analogous to the phenomena of life in structures that are unorganized. On the contrary, we see every thing in an opposite light. In an organized body, every organ is useful to every other organ, and no organ is made for the sake of itself alone; each sympathizes with all the rest, and each has a common interest in the welfare of the whole. The aliment which a plant or animal takes up, it distributes to every member. Manure and water the root of a plant, and the leaf and flower will soon give indications that they participate in the benefit conferred. Lop it severely, and the leaves and flowers will suffer. Give to an animal its due supply of food, and every organ is refreshed. Cut or chop off from it a limb, or part of a limb, and you excite a sympathy throughout the whole fabric, with a feeling of pain and of injury expressed by cries or manifested by contortions of body; but in unorganized bodies there is nothing of all this;—no unity or community of interests; no sympathy among the several parts; and no part that is necessary to the well-being of any other part. Cut or chop off any portion you please from a block of marble or from a perfect crystal, and the remaining portion shall know nothing of it, and will suffer nothing in consequence of it; in short, it will give no indication of being endowed with the attribute of life.

IV. *Aeration*.—No living being can thrive or even continue to exist without the access and contact of atmospheric air. The seeds of vegetables will not germinate if placed *in vacuo*. Ray introduced some grains of Lettuce-seed into the receiver of an air-pump, which he then exhausted. They did not germinate; but they germinated

upon the re-admission of the air, which shows that access of air is a condition necessary to the germination of seeds. [Phil. Trans, No. xiii.] The experiments of Homberg seem, indeed, to militate somewhat against this conclusion. They are recorded in the "Memoirs of the French Academy" for the year 1669; and the inference deduced from them is, that seeds in general do not germinate if deprived of atmospheric air; but that Cress-seed, Lettuce-seed, and a few others will germinate even in the vacuum of an air-pump. But the same experiments, when afterwards repeated by Boyle, Muschenbrock, and Boerhaave, with a much better apparatus, did not confirm the latter part of the result. On the contrary, they tended all to prove that no seed germinates in the vacuum of an air-pump; and that in the cases of germination mentioned by Homberg the vacuum must have been very imperfect. The same experiments were again repeated by Saussure the younger [Sur la Veg. chap. i. sec. 1], who says that the seeds of peas gave indications of germination *in vacuo* in the course of four days, but never effected any developement of their parts beyond the first appearance of the radicle. But is this a sufficient proof that germination had been really begun? Perhaps it might have been nothing more than the mere effect of the water distending their parts; and, perhaps, we should conclude upon the whole, that in a perfect vacuum no seed will germinate, but that in the most perfect vacuum hitherto formed by human art some seeds may germinate.

The same condition is necessary to the vegetating plant. Grew having discovered in a leaf that he was examining a number of little bags or bladders filled, as he thought, with air, drew the conclusion, and maintained the doctrine, that leaves are the lungs of plants. M. Papin, with a view to ascertain the point in question, introduced into the receiver of an air-pump an entire plant,—root, stem, and leaf. The consequence was, that it very soon died. He then introduced a plant by the root and stem only, with the leaves and branches exposed to the influence of the atmosphere. Still the plant died after a while, but it lived much longer than in the former case, and warranted him to conclude, as he thought, that leaves are indeed the lungs of plants. [Phys. des Arb., liv. ii., chap. 3.] Whether this conclusion was legitimately drawn from the premises or not, we will not at present stop to enquire. Enough was done to show that plants cannot continue to live without the access and contact of atmospheric air. They will not even grow with vigour unless they have an abundant supply; as he who has the management of a hot-house too often discovers to his cost. The plant that grows where there is no free circulation of air springs up slender and sickly. The plant that is exposed to the action of the stormy blast springs up stout and robust.

Of the truth of the same conclusion as applicable to animals, it will scarcely be necessary to offer any formal proof. It comes home so completely to every one's own experience, that he must needs be a bold man who would deny it. Yet if proof were wanted, it would be found in the death of many a poor mouse that has been placed in the receiver of an air-pump for the purpose of experiment.

There are, it is true, some apparent exceptions to the above rule. It has been said of the Truffle that it vegetates without the access of air, because it vegetates wholly under ground. But it is very well known that air penetrates the soil to a depth beyond that at which the truffle is found. It does not therefore vegetate without aeration. For the same reason it had been thought that the roots or bulbs of plants whose stem dies down to the ground in the winter, must vegetate without air. But air is conveyed to them in the moisture of the soil; and of some of them it may be said that they hybernate rather than vegetate in the winter. At any rate they are not deprived of the access of air. But it is in the animal kingdom that the exceptions are the most striking—not in the department of fishes, though their element is even the water; but in that of the amphibia. Live toads, snakes, and lizards have been found imbedded in solid masses of stone, or of coal at a great depth below the surface, and without any possibility of the access of air. [Phil. Mag. March 1817.] They are facts occurring about as often, and are about as well authenticated, as the sight of a Mermaid. We cannot well refuse our assent either to the one or the other; and yet we cannot give it but with a sort of sceptical reluctance. Yet if the fact in question is any thing different from that of a long protracted hybernation, we are altogether without the means of accounting for it.

V. *Temperature*.—The phenomena of life have never yet been exhibited except within a certain and limited range of temperature. Too great a degree of heat, or too great a degree of cold, is equally injurious to it. At a very low temperature, as towards the poles, plants and animals are often frozen to death. At a very high temperature, as at the equator, they are apt to perish through excess of heat. But they have the capacity of preserving their due temperature under the influence of many opposing causes. In the midst of the frosts and snows of winter, plants maintain a temperature which is always above that of the surrounding atmosphere; and even under the burning heat of a vertical sun their temperature is never raised very high. But different plants affect different temperatures, and you cannot well naturalize them in climates to which they are not indigenous. You may indeed have all varieties of them in the same latitude, but it shall be in the conservatory or hot-house; and if not, it shall be at different

altitudes. Tournefort noticed this in the case of the plants growing on Mount Ararat, and Humboldt gives us a similar account of the vegetation in the mountainous districts of South America. In ascending the Andes within the tropics, oranges, pine-apples, and all manner of delicious fruits and vegetables, are found on the lower grounds. Maize, plantains, indigo, cacao, at an altitude of from 3000 to 5000 feet. Cotton, coffee, sugar, at the same altitude, but ascending still higher. Wheat, and other European grains, together with the oak and other forest trees, at the altitude of from 6000 to 9000 feet. The pine still lingers at an altitude of 13,000 feet above the level of the sea. From 13,000 to 15,000 feet you have grass and lichen, which last creeps up still higher, adhering to the surface of the porphyritic rock, and insinuating itself even under the perpetual snow. [Humboldt's Narrative.]

Similar observations are the result of our enquiries into the animal kingdom. The bear is a native of the polar regions. The elephant, lion, and tiger, are indigenous only to countries near the equator. A forcible and sudden change of climate would be fatal, we may believe, to either. For although bears, lions, and elephants are found to live in countries of which they are not natives, it is only under the protection and fostering care of man. Man lives in almost all climates, but not with equal comfort. He can accommodate himself to cold climates by means of clothing; and to warm ones, by going without it. The Greenlander inhabits regions approaching to the latitude of 80° north, where the mercury freezes in the thermometer,—that is, at 40° below zero,—and yet the temperature of the blood never falls much below 98° of Fahrenheit. The negro lives under the hot and burning sun of the torrid zone, and yet the temperature of the blood never rises much above 98° of Fahrenheit—the temperature proper to the human body. The temperature proper to birds is still higher, varying from 107° to 110° . The temperature proper to the amphibia and fishes is much lower, and hence they have received the appellation of cold-blooded animals.

Further, plants and animals seem to be endowed with extraordinary capabilities in extraordinary circumstances. On the banks of a thermal river in the island of Luçon, the largest of the Philippines, Sonnerat found plants of *Vitex Agnus-Castus*, together with a species of *Aspalathus*, or African Broom, growing, and as we may suppose thriving, though the roots were swept by the water at a temperature of 174° [Voyage a la Nouv. Guinea, p. 38, 1771]; and in the thermal springs of Italy, though heated to the boiling point, certain species of *Confervæ* are said to grow abundantly. The same is the case with many fishes. In the above island of Luçon, Sonnerat saw fishes frolicking in a hot spring, the temperature of which was found to be

150°; and in the province of Quito, in South America, Humboldt saw fishes thrown up from the bottom of a volcano, together with water and heated vapour that raised the thermometer to 210°. This was quite high enough to have killed and boiled European fishes; but the fishes in question were still alive.

Wonderful as the above relation is, it is perhaps surpassed by the following facts; for man is capable of living, at least in atmospheric air, though heated to temperatures that are higher still. In 1760, when Duhamel and Tillet were conducting some experiments that required the heat of an oven, a girl was found who offered to go into it, to note the height of the thermometer, and who performed her task with the most perfect *nonchalance*; the mercury ultimately standing at 288°. The experimenters having subjected themselves to the same fiery ordeal, and the curiosity of the philosophers of this country being roused by the announcement of the fact, Sir Charles Blagden, Sir Joseph Banks, and several other men of science, exposed themselves, in an air bath, to a heat, first, of 220°, and finally of 260°, without suffering any particular inconvenience. The pulse was quickened to 140 beats in a minute. Water was boiled, and beef-steaks were dressed, and yet the temperature of the body never rose beyond 131° of Fahrenheit. [Phil. Trans. Abridged, xiii. 695.] Thus there is in plants, and in animals, something that resists and controls the influence of chemical agents, and that something is the attribute of life. The dead animal substances—that is, the beef-steaks—were broiled; but the living animal substances—that is, the hams of the philosophers—remained unaffected.

Connected with temperature we have the very singular phenomenon of the hybernation of plants and animals—that is, of some peculiar species of them, for all plants and animals do not hibernate. The state of hybernation is a state of torpidity induced by a low temperature, and lasting till the colds of winter have gone. The living functions are suspended. In plants there is no absorption, no nutrition, no flux of juices; in animals there is no respiration, no assumption of aliment, no circulation of fluids; or if this last process is at all carried on, it is in the most languid manner. Yet life is not extinguished. It is not even injured; but rather it is preserved from accidents that might be fatal to it; and when the return of spring restores again the due temperature, the individual resumes its living functions, and its hybernation ceases.

Among plants the bulbous-rooted are said to hibernate; and the bulb is regarded as being the winter quarters of the future plant. They do not, however, hibernate in the strictest sense of the term; for if you leave them in the soil for the winter, and inspect them now and

then, you will find traces of the growth and developement of the infant plant, even in the season of hybernation. But the hybernation of animals is the most complete. In them the living functions are really and truly suspended, and no traces exhibited of the growth of parts. The snake, the dormouse, the swallow, the bat, are examples of hybernating animals. They roll themselves up into the smallest compass possible, and, as it may best suit the species, take up their winter quarters in the earth, or in clefts of rocks, or in holes of walls exposed to the south. If you detect them in their hiding place, you may handle them, or pinch them, or roll them about, and they shall know nothing of it till they are exposed to the influence of warmth. Their torpor is said to be the most profound at the temperature of from 5° to 7° above zero. If they are suddenly exposed to a temperature that is either much lower, or much higher, they are roused indeed, into life, but the exposure kills them. The natural and gradual increase of returning solar heat is that which suits them best. Thus the attribute of life preserves them even in hybernation, and is ready to give them fresh activity when the due temperature returns. Much has been written about the annual disappearance of the swallows; some maintaining that they hybernate, and others that they merely emigrate. It is certain that such stragglers as have not joined in the general flight, do actually hybernate. This I can affirm with confidence from the fact of my having once found a solitary swallow in a torpid state, hybernating under the thatch that covered the ridge rafter of the roof of a carpenter's shop. It revived upon being exposed to the warmth of a fire. But either from its too sudden arousal, or from the weather's being still too cold, it soon died.

VI. *Death*.—By an irreversible decree of the original giver of life, every living being must submit to the stroke of death; which is, as we have already observed, an extinction of all living function, and of all possibility of living function. There is no exemption; there is no escape. There is no way of eluding the grasp of this ghastly king of terrors—*mors nescia flecti*—*mors ultima linea rerum*. It seems a hard condition, because it deprives us of all we hold dear. What a boon, what a blessing is life! and what would a man take in exchange for it? Even vegetables seem to be conscious of its value, though we regard them as beings destitute of the faculty of sensation. In the “fine frenzy” of the poet, the trees of the forest are made to rejoice, and the corn-covered valleys to laugh and to sing. [Psalm lxxv.] Much more is the blessing of life cognoscible by animals who are endowed with organs of sense and feeling. See how the tender lamb frolics in the enjoyment of its newly acquired existence! See how the birds wanton in air! See, above all, how man appreciates the

value of the gift; and see his "longing after immortality;" when participating freely in the gratifications which life presents, he reflects upon the plenitude of its delights, and, mingling religion with his mirth, ascends in holy contemplation to the idea of a kind Creator, and even to the glories of a future world.

However, life is liable to many accidents that tend to cut short the thread by which we hold it. Wounds, diseases, poisons, are often fatal to the life of man, as well as to that of other animals, and of plants also. A violent blow on the temples will extinguish life in an instant. Plague, pestilence, and famine will speedily produce the like effect; and a few drops of concentrated Prussic acid introduced into the animal circulation, will cause almost immediate death. But if the individual should fortunately escape all fatal accidents, still a term will come beyond which life cannot be protracted—still it will be worn out at last by a natural and gradual decay. Observe its progress in the plant, and the symptoms of approaching dissolution: the root refuses to imbibe the nourishment afforded by the soil;—the juices are but feebly propelled, and their assimilation effected with difficulty;—the bark becomes thick and woody, and covered with moss or lichens;—the shoot becomes stunted and diminutive, and the fruit palpably degenerate, both in quantity and quality;—the terminal branches fade the first, then the larger branches, and then the trunk and root;—the vital energy of the fabric languishes, and is at last totally extinguished;—and the plant, now exposed to the chemical agencies of surrounding substances, which it cannot any longer resist, withers and dies away, presenting to the eye a decayed and rotten appearance, and crumbling into the dust from which it originally sprang.

Observe its progress in the animal, and you will find that the symptoms are of a similar character. It has been said, indeed, of man, that it is the body only, and not the mind, that suffers decay and death. But it is evident that the mind is liable to decay and to death as well as the body. If the organ perishes, its function must inevitably perish. If the brain dies, its function—mind—must cease. As well might you expect that the faculty of digestion should continue when life has left the stomach, as that mind should continue when life has left the brain. If the eye becomes dim, and the ear dull of hearing, and the palate incapable of tasting, and the nostril devoid of smell, so the memory becomes weak, the judgment erroneous, the understanding embarrassed, the will slow in its decisions, and the organs that are subject to it slow in their obedience; inducing "second childishness and mere oblivion;" and exhibiting man in his state of dotage, "sans mouth, sans teeth, sans eyes, sans every thing." It is but a

step further to the total extinction of life, and cessation of all living function,—that is, in other words, to the death both of the body and the mind.

During life all was activity, all was vital or spontaneous motion, all was the exercise of organic function.—In plants, absorption, assimilation, and distribution of fluids, with growth and developement of parts; in animals, prehension, digestion, and assimilation of food, with growth, locomotion, intellection; and in man the faculty of speech,—referable to the agency of that subtle, invisible, and incomprehensible something called life, which counteracts and controls mechanical and chemical agencies, and converts them to its own purposes. If I move my arm from the pendent position, and raise it to a horizontal or upright position, the agency of gravitation is counteracted. If the materials that compose the living fabric do not tend to putrefaction, the agency of chemical affinities is counteracted. But in death there is no longer any resistance opposed to these agencies; no living action, no spontaneous motion, no exercise of organic function: in short, the fabric is no longer a living system. Chemical and mechanical agencies “possess it merely,” exerting themselves in their full strength, and reducing it, sooner or later, to the primordial and elementary principles out of which it was originally formed.

Sleep has been said to be the image of Death. But it is only a transient suspension of some of the functions of life. The exercise of function fatigues the organs, and hence they require a period of repose. Such is sleep, which lasts only till the fabric is recruited. Hybernation might be said to be the image of death also, but it depends entirely on temperature. When the temperature sinks to a given degree, hybernation begins; and when it rises again to the same degree, the exercise of function is resumed. But if death once supervenes, its dominion is perpetual, and its empire not to be escaped from. It is “the undiscovered country from whose bourn no traveller returns”—“the cheerless night that knows no morrow”—

“ Omnes una manet nox,
Et calcanda semel via lethi.”

HOR. ODE XXVIII. Lib. i.

—that is, as regarded in a physiological light. For the morning that is yet to “dawn on the night of the grave,” we are not taught to look forward to as a consequence resulting from the established order of things, but as an event emanating from the *fiat* of the Almighty. [1 Cor. xv. 51.]

Thus the phenomena of life and of death are plainly and palpably distinct. They are opposite and irreconcilable, and cannot be mis-

taken. Life composes, death decomposes; life rears a fabric, death destroys it; where life extends, the integrity of the fabric is maintained; where life ends, decomposition with putrefaction begins. Such is the victory achieved by death, and the inevitable doom of every thing that lives!

LIGHT.—Concerning the nature of light there are two grand and leading theories. The first regards it as being a material emanation issuing from the surface of luminous bodies, under the form of infinitely minute particles, which, being propagated in all directions, and reflected from all non-luminous surfaces, ultimately reach the eye, and excite the sensation of vision. The second regards it as being merely an undulation of an unknown, invisible, and every-where-existing fluid called ether, excited by the presence of luminous bodies, and extending in all directions, as well as reflected from all non-luminous surfaces, till it ultimately reaches the eye and produces the sensation of sight.

At the head of those who support the former theory stands the immortal Newton, who, by means of it, explains the whole of the phenomena of vision so very satisfactorily that we cannot well suppose it to be founded in error. At the head of those who support the latter theory stand Huygens and Euler, who, though they failed to establish their own hypothesis, succeeded, however, in starting such objections to that of Newton as have led to the later enquiries of Young, Arrago, Fresnel, and others, the issue of which seems to be a preponderance of argument in favour of the doctrine of undulations.

It is not our object to enquire into the merits of these rival theories. We introduce the subject of light merely on the score of its influence on the process of vegetation, whether in the direction of the stem or branches; the position of the leaf, the expansion of the flower; the colouring of the plant; the decomposition of carbonic acid, and consequent evolution of oxygen; or in the forwarding of the maturity of fruits or seeds. See **EXCITABILITY, ELABORATION OF OXYGEN, ELABORATION OF CARBONIC ACID.**

LIGNEOUS LAYERS.—The ligneous layers are the concentric and annual layers, of which the woody part of exogenous plants are composed; soft at the circumference of the stem, but more solid at the centre. See *Ligneous layers*, under the head of **CONCENTRIC LAYERS.**

LIGNIN.—If a piece of the stem of a herb, shrub, or tree, is taken and well dried, and afterwards digested, first in water and then in alcohol, or such other solvents as shall produce no violent effect upon the solid parts, and if the digestion is continued till the liquid is no longer coloured, and dissolves no more of the substance of the plant, there will remain behind a sort of skeleton which constitutes the basis

of the vegetable structure, and amounts to about 96 or 98 per cent. of the weight of the different kinds of wood. It has been by some chemists denominated Woody Fibre [Thomson], and by others Ligneux [Raspail]. We believe there is now a leaning towards the use of the term *Lignin*, which we consequently adopt; though it is plain that it differs from wood or herb only in the want of such ingredients as have been abstracted by digestion. According to Raspail it is composed of cells, tubes, and spirals yet visible. The cells, which have been organs of elaboration, abound in the younger parts and in the pith. In the epidermis they are much flattened, in the pubescence they are much elongated. The tubes, which have been organs conducting the sap or juices, abound in the woody parts, forming layers of a sort of net-work, or insulated bundles. The spirals, whose office has been that of conducting air, abound in all phænogamous plants, but especially in the leaves. [Nouv. Syst. de Chim. 79.]

When lignin is distilled in a retort, it yields an empyreumatic oil, carburetted hydrogen gas, carbonic acid gas, and, according to Fourcroy, a portion of ammonia indicating the presence of azote as constituting one of its elements. [Thomson's Chem.] By the analysis of Gay Lussac and Thenard, 100 parts of Lignin contain of carbon 52, and of oxygen and hydrogen, in the ratio which forms water, 48. Thus it is reducible to precisely the same elements as wood. See WOOD.

LIMB.—The expanded border of a monopetalous corolla, or the upper and dilated part of an individual petal of a polypetalous corolla, is usually designated by the appellation of the limb—*limbus*, *lamina*.

LOBE.—The larger portions into which some simple leaves are naturally divided are called lobes, and so also are the cotyledons of the seed. If the plant is monocotyledonous, the lobe is single; if the plant is dicotyledonous, the lobes are in pairs.

LOCULI.—The little cells of the anthers which contain the pollen are, in the language of botany, called Loculi.

LOCULICIDAL.—A mode of the dehiscence of fruits. See PERICARP.

LOCUSTA.—The individual spikelet that makes part of the general spike of many of the Grasses, as in *Bromus*, furnished at the base with a perianthium consisting of two opposite glumes, is by modern botanists denominated a *Locusta*.

LOMENTUM.—Besides the varieties of legume which we have already pointed out, there is a peculiar variety of it which, though externally forming longitudinal sutures, to one of which only the seeds are attached, does not yet open longitudinally by means of two general valves; but transversely, by means of joints, each joint forming a cell that contains one seed, which is finally extricated by the opening of

the individual joint. This variety of legume was regarded by Willdenow as constituting a distinct species of *Pericarp*, and designated by the name of the *Lomentum*; but is a distinction to which it seems scarcely entitled.

LONGEVITY OF PLANTS.—Though many plants are merely annuals, or biennials, yet there are also many which are perennials, and some which live to a most extraordinary age. We have no infallible rule, it is true, to enable us to determine a plant's age precisely, if we are ignorant of the date of its escape from the germinating seed; but we have marks that enable us to come pretty near to the truth.

I. In exogenous plants, the rule is to take the number of the zones, or circular layers of wood, as discoverable on the transverse section of the base and of the trunk, when the tree is felled, counting them from the pith to the circumference, and to give a year to each. But if this cannot be done with the tree whose age you wish to ascertain, perhaps you may be able to do so with some other tree of the same species, whose age you know,—and then say—As a diameter of a certain width is to a certain number of layers, so is a diameter of a certain other width to a certain other number of layers, or to the age of the tree. This is the approximation; and it must be admitted that it is an approximation merely. For it is by no means proved that there is only one layer formed in the course of a year, and never more than one. On the contrary, Duhamel has shown that a tree of twenty years old has not always twenty distinct layers; and that a tree of ten years old has sometimes more than twelve. [*Phys. des Arbres.*] An excess of layers may be easily accounted for. If a recurrence of cold weather, after a warm and forward spring, should happen to check or suspend vegetation but for a short time, the recommencement of the process will be again marked by a new layer, as it was in the beginning of the spring, and two layers instead of one will be the result of the growth of that year. A deficiency of layers may be accounted for with equal ease. Unknown causes effecting a consolidation of two contiguous layers, and effacing the mark of distinction between them, will make the two to count as if but one, and thus occasion an apparent diminution at least in the true number of layers. Still the general rule is good, and may be followed, as we think, with safety. In the celebrated *Sylva* of Evelyn, we have an abridged view of almost all that the ancients have written on the subject of the longevity of trees. But the representations there exhibited are in general so vague, and so very full of the marvellous, that we forbear repeating them, and confine ourselves to accounts of a more recent date.

1st. *The Elm-tree.*—Evelyn speaks of an Elm-tree that stood on Binsey Common which measured six yards in diameter near the ground.

It was not remarkable in any other respect; but in thus giving evidence of a very great antiquity. [Sylva, chap. xxx.] Decandolle has a case which he gives with more of detail. An Elm-tree that grew at Morges, on the bank of the lake of Geneva, fell down or was blown down in 1827. The trunk measured about eighteen feet English in diameter, taken at the base, and sixteen feet a little below the branches. The zones, allowing a zone to a year, announced an age of 335 years at a mean of diametral increase of $3\frac{1}{2}$ lines per annum. [Phys. Veg. ii. 985.]

2nd. *The Ivy*.—M. Decandolle saw a plant of Ivy in 1814, at Gigean near Montpellier, which grew by a garden wall in a very dry soil. At the base it measured six feet in circumference, giving origin to two large trunks that measured each five feet in circumference. It covered upwards of forty square yards of wall, having an elevation of eighteen feet. The horizontal section could not be got at. But as the means of making at least a plausible guess at its age, M. Decandolle cut down another plant of the same species, which he knew to be forty-five years of age. Its circumference was only $7\frac{1}{2}$ inches, which, by the application of the rule of proportion, gives to the Ivy-tree of Gigean an age of 433 years. [Phys. Veg. ii. 986.]

3rd. *The Lime-tree*.—The Lime-tree of Neustadt on the Kocker, in the kingdom of Wurtemberg, has obtained much celebrity on account of its extraordinary size and age. It was already a large and notable tree in 1229, as appears from the records of the city itself, which was founded in that year, to supply the place of Helmbundt, that had been destroyed by an earthquake in 1226. The new town or city was built near it, and Evelyn, who saw it in 1664, remarks that it was better known than the town itself, which people spoke of as Neustadt near the great Lime-tree. It measured thirty-seven feet four inches in circumference, measure of Wurtemberg; and its lower branches, which were trained horizontally, were supported by columns of stone, then eighty-two in number, having inscriptions, some of which were so ancient as 1530. [Sylva, chap. xxx.] In 1831 it was again visited by Trembley, when it gave a circumference of thirty-seven feet, six inches, two lines, at six feet from the ground, which at two lines of diameter per annum gives it an antiquity of from seven to eight hundred years.

4th. *The Walnut-tree*.—Evelyn gives us an account of a wonderful Walnut-tree that grew at St. Nicholas's in Lorraine, and seems to have been quite a monster in the enormity of its dimensions. A single slab cut out of the trunk measured twenty-five feet in breadth by a length and thickness in due proportion. Where they got the saw to cut it, we are altogether at a loss to guess. But the slab was

seen, as it is said, by Scammozzi the architect; and Decandolle, who seems to have read Evelyn's account of it, and to have misunderstood it, finds out a use for it immediately suitable to its great dimensions, and makes the Emperor, Frederick III., in 1472, to give a grand and magnificent entertainment to this numerous retinue on this enormous slab, "*sur ce bloc monstreux*." [Phys. Veg. ii. 994.] At what an awful distance the nobles on the opposite sides must have sat from one another; and how did they get at the fruit and other nice things that were doubtless placed at the centre? But what does Evelyn say?—Such a monster *that* [tree] might be, under which the Emperor Frederick III. held his magnificent feast in 1472. [Sylva, chap. xxx.] Decandolle conjectures that the tree which furnished this capacious and hospitable board, could not have been less than 900 years of age.

5th. *The Chestnut*.—The famous chestnut of Mount Ætna, known in Sicily by the name of *Castagno di cento cavalli*—the hundred Horse-tree—from its having sheltered Jane of Arragon and her hundred attendant nobles within its hollow trunk, in a storm, is certainly one of the largest and oldest trees in existence. The lowest measurement gives it 160 feet of circumference at the base, the highest 180. It is regarded, however, as being a sort of natural graft of several contiguous trunks, rather than a simple and undivided stem, and on this account, its age, extraordinary though it must be, cannot be satisfactorily determined. But the great Chestnut-tree of *Sancerra*, which, according to Bosc, now measures thirty-seven feet in circumference, and which went by the name of the great Chestnut-tree, 600 years ago, is regarded by Decandolle as being not less than 1000 years old. [Phys. Veg. ii. 995.]

6th. *The Cedar*.—Of the celebrated cedars of Lebanon, so highly lauded in Holy Writ, as existing in the earlier periods of the Jewish monarchy, perhaps there are none now remaining. The havock that was made among them by Solomon, or by Hiram, at the time of the building the famous temple of Jerusalem, seems to have all but exterminated them. They have never thriven since, in this station; so that it may truly be said, "The glory of Lebanon is departed." In 1550 Belon counted twenty-eight. In 1609 Lithgow counted only twenty-four. In 1699 Maundrel counted only seventeen; and in 1789 Labillardiere says they had dwindled away to seven. Maundrel measured some of the largest of them. They were twelve yards and six inches in circumference, giving a diameter of 1527 lines. But if they grew at the rate of four or five lines of diameter in a year, as some cedars have done in this country, it would not even now give them more than 1000 years of age. But I think it likely that cedars on the

exposed heights of Lebanon would be of less rapid growth than such as have been planted in the well-sheltered pleasure grounds of Chelsea Gardens, or of Hendon Place, and would have given a greater age to the same diameter. On this principle we may regard the cedars of Lebanon now in question as being at least 1200 years old.

7th. *The Oak*.—The oak-tree is particularly well known for the great size and age to which it often attains. Evelyn, in his account of the aged oaks of England, speaks of one that grew at a place called Rivelin, and went by the name of the Lord's Oak, which measured thirty-six feet in circumference at a foot from the base, which, at an increase of two lines per annum, gives an age of 864 years. [Sylva, chap. xxx.] In Samogitia, a province of Poland, an oak-tree was felled in 1812 that measured thirty-nine feet in circumference near the base, which, at the highest supposable increase of diameter, gives an antiquity of at least a thousand years. But an Oak-tree that was felled in the Ardennes in 1824, containing in the interior of the trunk coins and medals of the ancient Samnites, must have been much older, as we have reason to think, than either of the above. For if we only suppose the coins to have been deposited in it about the time of the irruption of the Goths and Vandals, when men were compelled to conceal their treasures for fear of being plundered of them, we shall have an antiquity of at least fifteen or sixteen centuries. [Dec. Phys. Veg. ii. 1000.]

Yet all these are but pigmies to the celebrated oak of Colthorpe, near Weatherby, which still exists, and which measures seventy-eight feet in circumference, close to the ground, and forty-eight at the height of a yard. The trunk, now hollowed out by age, is said to be capable of admitting upwards of seventy persons at a time. If we estimate its standing upon the principle of the usual rule, we shall have to give it an antiquity of upwards of 2000 years. [Keith's Phys. Bot.]

8th. *The Yew-tree*.—The yew-trees of Rippon in Yorkshire are often quoted as exhibiting marks of great antiquity. Tradition says that they served to shelter the Monks of Fountain's-Abbey in 1133, while their abbey was rebuilding. They were measured by Pennant in 1775. The largest gave a circumference of $26\frac{1}{2}$ feet, equal to 1214 lines of diameter, which at the rate of one line per annum, enough for a yew-tree, gives consequently an age of 1214 years; to which, if we add the years that have since elapsed, we shall have an age equal to 1280 years.

But of all the yew-trees in Britain, or out of it, none was ever heard of equal to that which grew in the churchyard of Brabourne, in Kent, as recorded by Evelyn, who measured it in 1660, and describes it as

being then superannuated. Its circumference at the base was all but sixty feet [Sylva, chap. xxx.], giving a diameter of not less than 2880 lines, which is equivalent to an age of 2880 years; and if it still exists, says Decandolle, we may set it down as being of the age of 3000 years. In reading the above account, preparatory to the drawing up of an article on the Longevity of trees, I began to take shame to myself for having lived, at least twenty years, within a few miles of Brabourne, without having ever had curiosity enough to take me to the tree. But, to make amends for a fault, I resolved to set out upon a visit to it the very next morning. On the following morning I was, accordingly, on my way, and in nearing the churchyard my curiosity was raised to the highest pitch. At last I entered the churchyard, and saw, as I expected, a yew-tree; but alas! no more like the yew-tree of Evelyn, "than I to Hercules." It was a puny thing in comparison, not more than four or five yards in circumference at the very base. It was not of course the yew-tree Evelyn measured. What had become of it?—It could scarcely have rotted away entirely in the course of 175 years; and one would suppose that it must have been reckoned sacrilege to carry it away to burn it. Yet there is no tradition concerning it among the inhabitants of the parish. The oldest of them never heard it spoken of by their forefathers, or ever met with any vestige of it whatever. Yet I found I was not the only person that rumour had brought to Brabourne in search of the wonderful yew-tree. A few months previous, an Oxford student who had been attending lectures in Botany, having had his curiosity excited by the representations or assumptions of the lecturer, started, and came post to Brabourne, on the same errand with myself, and met accordingly with the same disappointment.

How all traces of it should have so completely disappeared, as to have left not even a parochial tradition behind, I cannot say. But let no one, for the future, take a journey to Brabourne-churchyard in the hopes of seeing Evelyn's enormous yew-tree. Yet, as being, perhaps, the nearest approximation to it that Kent affords, if any one will be at the trouble of visiting the churchyards of Stalesfield, and of Easling, near Charing, he will find in each of them, a yew-tree measuring nine yards in circuit, at the height of four feet from the base,—the former hollow, the latter sound; giving, at the rate of one line of diameter per annum, an age of 1296 years.

9th. *The Baobab*.—Lastly, the Baobab, *Adansonia digitata*, is, perhaps, of all known plants, that which attains to the most advanced age. In its native country it goes by a name that implies a duration of a thousand years, though it often surpasses that period. Adanson found one on the banks of the Senegal that gave, by admeasurement,

a diameter of twenty-seven feet. He found also another in one of the Cape Verd Islands that had been noticed by two Dutch or French voyagers, two or three centuries before. They had inscribed their names deeply on the trunk; and the inscriptions, which were not yet quite obliterated even in 1749, Adanson restored, by widening and deepening the letters. The tree had then a diameter of not more than six feet. It was thus comparatively but a young tree. The letters, as originally inscribed, had a length of six inches; but from the small space which they occupied horizontally, Adanson thought the diameter could not have been more than about three feet when they were originally cut out; so that, in the space of 200 years, the diameter had increased by a width of two or three feet; which would give to the immense Baobab that he saw on the banks of the Senegal, a longevity of about 5000 years, and to the largest that has ever been measured, a longevity of nearly 6000 years, or a period about equal to the age of the world we inhabit. [Famil. des Plant. i. 212, 216.]

10th. *The Cypress*.—Finally, there is a species of Cypress, *Cupressus disticha*, that seems to outlive even the Baobab. It grows plentifully towards the southern extremity of North America. An individual of this species, that grew near Oaxaca in Mexico, measured 117 feet 10 inches French in circumference, $37\frac{1}{2}$ feet in diameter, and 100 feet in height. It is mentioned by Cortes, who is said to have sheltered his whole army under its shade; it is regarded by the native Mexicans with the most profound veneration. Decandolle thinks it shows marks of being older than any Baobab. [Phys. Veg. ii. 1006.]

II. In endogenous plants the rule is different, owing of necessity to the peculiar mode of augmentation, as in the case of the palms. For in them you have no annual and circular layers to count, and no indication in the width of diameter. You have, in short, nothing to guide you but the circular marks that have been left, at intervals, on the exterior of the trunk, by the decay of the fibres of the leaves of each year, as the plant grows in height; and even these you have not in all species, and but partially in any. For the young parts do not show them, and in the old parts they are effaced. Hence the rule is founded upon the actual height of the plant, rather than upon width of diameter. Suppose that the problem to be solved is the ascertaining of the age of any individual palm. Let the enquirer ascertain the height of some other individual of the same species, whose age is known to him, or take it as ascertained by any one else, and then say—As a certain height is to a certain number of years, so is a certain other height to a certain other number of years, or to the age of the plant in question. It is but a rough guess at the best, but is all that can be achieved.

First. A Date-tree, that was planted in 1709 at Cavalaire in Provence, had attained in 1809 to the height of fifty feet, with a diameter of eighteen inches. This gives an upright growth of six inches in the year for trees of this species; but they are said to live till they are two or three hundred years old, without increasing in height beyond 60 feet. Second. The Ceroxylon of the Andes attains to a height of 180 feet, and is thought to live to the age of 900 years. Lastly, the famous Dragon-tree of Orotava, *Dracæna Draco*, measures, according to Humboldt, 45 feet in circuit near the ground, with a diameter of 16 feet. When the Isle of Teneriffe was discovered in 1402, tradition says that it was then as large and as hollow as it is now. [Dec. Phys. Veg. ii. 1014.] What then must be the age of that tree on which the tear and wear of four centuries has scarcely made any impression? though it is evidently in a state of decay.

Such are a few of the most noted examples of the protracted vitality of vegetables which seem to have long outlived the average age of their species; emulating, or rather surpassing, in length of years, the most durable monuments of human art, and claiming that venerable regard which men seem spontaneously to bestow upon objects of extraordinary antiquity. It is not the antiquity of rocks or of mountains that we here contemplate and admire—mountains capped with eternal snow, which nothing can disturb but the most violent convulsions of nature, without organs and without functions as they are,—but the antiquity of beings endowed with life—of beings composed of a variety of delicate and complicated organs, requiring a regular supply of nutriment to keep the several vital functions in exercise, and liable to a thousand accidents to cut short the thread of life. The animal kingdom affords no examples of longevity equal to those we have now enumerated. What was the age of Adam, or of Methuselah, compared to that of Evelyn's yew-tree or of Adanson's Baobab? Nothing! So that if vegetables stand lower in the scale of being than animals, many of them enjoy, at least, a more protracted existence, and have the privilege of remaining longer the living monuments of the power of the Creator.

LUPULINE.—If the catkins of the female hop are shaken in a bag or sack, a yellow powder is separated from them, composed of cells or vesicles that contain thousands of smaller cells or vesicles, or globules, within them. If one or more of these vesicles is let fall on a drop of water placed on the stage of a microscope, it no sooner comes in contact with the fluid than it explodes, expelling the smaller globules, like the powder of the pollen, sometimes scattered and sometimes in groups, and sometimes in prolongations resembling pollen tubes. Chemists regard this powder as a peculiar substance, and give

it the name of *Lupuline*. It constitutes from 9 to 12 per cent. of the weight of the catkin, and is believed to be the material, on account of which hops are so generally employed in the manufacture of beer. M. Raspail describes and figures it, and regards it as being analogous to pollen, not only in its physical and chemical properties, but also in its use in the vegetable economy; believing it to be capable of effecting the fecundation of the seed without the intervention of male organs, as the glands found on the calyx of *Cannabis sativa* are also known to do; thus vindicating the accuracy of the observations of Spallanzani, and reconciling them with those of Linnæus. It is composed of resin, wax, and bitter extract, soluble in water and alcohol. It seems to be neither acid nor alkaline; and may be obtained from the leaves, as well as from the catkin-scales, of the Hop. [Nouv. Syst. 174.]

LUTEOLINE.—The plant called *Reseda Luteola* has been long known in the arts from the yellow colouring matter which the dyer extracts from it. This dye M. Chevreul regards as a peculiar substance, to which he gives the name of *Luteoline*. It crystallizes by sublimation in transparent needles, slightly yellow. It is said to be scarcely soluble in water, but it is soluble in alcohol and ether, and acid, rather than alkaline. [Dec. Phys. Veg. 367.]

LUXURIANT FLOWERS.—If the usual number, whether of the petals, stamens, or pistils, proper to any flower, is unduly augmented, to the exclusion or diminution of either of the other parts, the flower is then said to be luxuriant; of which case there are three principal varieties,—the multiply flower, the full flower, and the proliferous flower—which see.

LYMPH.—The water of the soil, when taken up by the spongioles of the root and received into the vessels destined to convey it to the elaborating organs, assumes the appellation of *lymph* or *sap*, which terms are synonymous and convertible, though we have generally made use of the latter in speaking of the fluid which they designate, as in the Ascent of the Sap, and Elaboration of the Sap, to which we refer the reader.

LYMPHATICS.—The vessels by which the sap or lymph is conveyed from the extremity of the root to the extremity of the stem or branch are often designated by the appellation of *lymphatics*.

MACE.—The aril which envelopes the shell or internal pericarp of the nutmeg is the mace of the shops, so much esteemed for its delicate flavour and relish, and for its utility in the art of cookery; or, as M. Ude would say, in the science of gasteronomy.

MACULÆ INDICANTES.—The coloured spots with which many flowers

secreting a honied fluid are marked, Sprengel designated by the name of *Maculæ indicantes*, as indicating the treasure that is contained in the flower, and thus attracting the notice of insects.

MALATES.—Malate of lime is said to be found in the root of *Aconitum lycoctonum*, of *Nymphæa*, *Asclepias*, *Glycyrrhiza*, and *Bryonia*; and malate of potass in the root of *Polygala Senega*.

MALIC ACID.—This acid is very generally diffused throughout the vegetable kingdom. It is found in almost all fleshy fruits, as apples, plums, raisins, gooseberries, from the juice of which it is obtained, by processes known to the chemist. It is not easily crystallized, but if left exposed to the air it becomes thick and viscous. Nitric acid converts it into oxalic acid; and in the process of the ripening of fruits it passes into a state of sugar.

MANNA.—From the bark of *Fraxinus Ornus*, a tree that grows plentifully in Sicily and Calabria, there exudes a secretion known by the name of Manna; whence the tree itself is often designated by the appellation of the Manna-ash. Yet the exudation does not take place spontaneously. It is occasioned, as it is said, by the puncture of an insect, or by artificial incisions made in the bark about the end of July. The secretion is not altogether peculiar to the ash: there is a species of *Tamarix* growing near Mount Sinai, *Tamarix Mannifera*, that yields it also. It seems to be a compound of several different ingredients—gum, bitter principle, and a little sugar, together with the substance described in the following article.

This heterogeneous exudation, which ultimately drops from the leaves or branches in globules of about the size of a pea [Athenæum, No. 427], covering the ground beneath like a sprinkling of hail, as we may suppose, has been regarded by some as being the *Manna* on which the Israelites fed during their journeyings in the wilderness. But as we have no reason to believe that it either was, or could have been, thus produced within or near the precincts of their encampments, in quantities sufficient to supply the daily demand for bread of more than a million of human beings, we are persuaded that most men will be disposed to fall back on the scriptural account of its miraculous origin, as given by Moses, and to take refuge in the sanctuary of faith.

MANNITE.—Mannite is that ingredient in the composition of manna which chemists regard as a peculiar substance. It crystallizes in fine needles, is soluble in water and in alcohol, and, when treated with nitric acid, is, like sugar, converted into saccolactic acid; but it differs from sugar in its composition, as containing an excess of hydrogen. [Dec. Phys. Veg. 240.]

MARGIN.—The outline that bounds the expansion of the leaf or petal is the margin.

MANURES.—It is a fact well known to the cultivator, that certain substances, if introduced into the soil and duly mixed with it, will accelerate vegetation and increase the bulk and value of crops. Such substances are called manures. They may be either of mineral, of vegetable, or of animal origin. If of mineral origin, they affect the soil merely; if of vegetable or animal origin, they enter the plant and are assimilated to its substance.

First. Mineral manures are silica, lime, alumina, under the modifications of sand, clay, lime-stone, chalk, marl, sea-shell, gypsum. They do not actually or directly supply a vegetable food, but their ameliorating effect consists in their improving or correcting the texture or absorbing power of a faulty soil. Thus, if any soil is found to contain sand in excess, so as to be too open for the purposes of agriculture, the fault may be corrected by the application and admixture of a due proportion of clay, marl, warp, or sea-shell; and in this way the sandy soils of Norfolk and Suffolk have been ameliorated to a degree surpassing all previous expectation. A gravelly soil, if too open, may be ameliorated in the same way. On the other hand, if any soil is found to contain clay in excess, so as to be too retentive of moisture, and too wet for profitable cultivation, the fault may be corrected by the application and admixture of a due proportion of common sand, sea-sand, or of limestone gravel. But lime is beyond all others the mineral substance that is the most commonly used as a manure. It exists in this country in great abundance, under the modifications of chalk, marl, limestone. The two former are often applied to the soil directly—that is, in the state in which nature produces them; and besides the property which they possess of improving the texture and absorbing power of the soil, they are thought to have the additional property of giving stiffness and whiteness to straw, and thinness of rind to grain. The latter cannot be applied to the soil till it is either calcined—that is, burnt—or pounded. If, after calcination, it is applied in the state of quicklime, it accelerates the decomposition and solution of vegetable substances, so as to render them a fit food for the vegetating plant. But if it is not applied till it becomes again a carbonate, which by exposure to the atmospheric air it does, it acts then merely as chalk or marl; and in its pounded state it acts in the same way. Gypsum, which is a sulphate of lime, has been used as a manure also with much advantage, and its application seems to be the most efficacious when it has been previously ground to a powder.

Secondly. Vegetable manures are weeds, pond-weeds, sea-weeds, green crops ploughed in, malt-dust, rape-cake, linseed-cake, tanners' spent bark, straw, wood-ashes, peat;—all of which, in being mixed

with, and ultimately decomposed in, the soil, present to it directly the grand materials of vegetable food,—carbon, hydrogen, oxygen,—which plants, through the medium of the root, are capable of absorbing in solution or in combination, and of assimilating to their own substance. Weeds should be taken before they run to seed, to prevent them from springing up again; and committed to the soil before they are much withered, to prevent their volatile parts from being dissipated in the atmosphere; and green crops should be ploughed in when in flower, because they then contain the greatest quantity of easily soluble matter. [Davy's Agri. Chem. 244.]

Thirdly. Animal manures are either animal carcasses, which are not very generally used entire, except in the case of fish, as herrings, sprats, pilchards; or they are animal substances, as offal, blood, blubber, bones, horn, hair or wool, feathers, dung, urine. These, in the process of decomposition, when mingling with the soil, present to it, like vegetable manures, materials which the plant can readily absorb and assimilate. They are eagerly sought after by the farmer, and are by far the most efficient of manures, abounding, beyond all others, in easily soluble matter, and in carbon, oxygen, and hydrogen, the elements of which plants are composed.

Fourthly. Composts are artificial mixtures of mineral substances, or of mineral and vegetable substances, or of mineral, vegetable, and animal substances, laid in heaps and left to ferment for a time, in order to prepare a rich, efficacious, and manageable manure. After a certain period of repose the heap is turned, and after a second period of repose it is turned again. The more frequently it is turned, the more is its fermentation excited; but if the mixture contains vegetable or animal substances, there is a danger of carrying the fermentation too far, and of dissipating the most nutritious elements of the compost before it is applied to the soil. This error the judicious farmer will be careful to avoid, that he may not sacrifice the fertility of his manure to the distant and unprofitable pleasure of tossing about *short muck*; and thus lose the substance in the pursuit of a shadow.

MARL.—This fossil, which is obtained by digging pits in localities producing it, is a carbonate of lime, or of lime and clay, much used as a manure, particularly in the way of top dressings on grass lands. But it is applied also to lands under tillage, and ploughed in after being spread over the surface and exposed to a winter's frost. [Code of Agri. 237.]

MASTIC.—This resin is the produce of *Pistacia Lentiscus*, a tree which grows plentifully in the island of Chios. It exudes in a fluid state from incisions made in the stem, and concretes into brittle grains,

yellowish and semi-transparent. In this state it is sold under the name of mastic. It has scarcely any taste, but when heated it melts, and exhales a fragrant odour. It is said to be sometimes employed as a varnish.

MECONIC ACID.—An acid found hitherto only in opium, the proportion of whose elements is not known. See **OPIUM**.

MEDULLARY RAYS.—If a horizontal section of the stem of the Oak or Elm is taken and inspected even with the naked eye, it will be seen to be composed of two sets of layers crossing one another, the one circular and concentric, the other divergent from the centre. To this last set the appellation of Medullary rays has been applied by some phytologists, upon the presumption that they proceed from the pith, though it is but a few of them that can be fairly traced to it. See **DIVERGENT LAYERS**.

MEDULLARY SHEATH.—The first layer of longitudinal fibres surrounding the pith is called the Medullary Sheath.

MEDULLINE.—The cellular tissue of the pith of Dicotyledonous plants, deprived of all its juices, and no longer discharging any living function, has been regarded by M. Chevreul as constituting a peculiar substance, to which he gives the name of *medulline*. But M. Raspail regards it as being merely lignin, reduced to its simplest form, and state of greatest purity; so that we may fairly say of it—*sub judice lis est*.

MEMBRANE.—Membrane is that thin and filmy substance of which the cellular tissue whether of vegetables or of animals is composed, being the first visible result of the transformation of gases, or of liquids, into a solid and concrete form; and the primary and fundamental basis of all organic fabrics; unless we say that the film is itself composed of the finest molecules imaginable laid closely side by side.

METALS.—Among the substances composing the ashes of vegetables, chemists enumerate metals. They occur only in small quantities, and in the state of oxides, and are not detected but by the most delicate experiments. Yet of the thirty or forty metals now known, three or four only have been found in plants. Of these, iron is by far the most common, as is said to have been detected in the root of briony, in the bulb of garlic, in the leaves of the olive, and in the fruit of *Areca betel*. Manganese was first detected by Scheele, and afterwards by Proust in the ashes of the vine and fig-tree. M. Bischoff is said to have detected copper in the ashes of *Lycopodium complanatum*; and Kunckel fancied he had detected gold, but in what plant I know not.

METHOD.—A method, in the language of botany, means merely a mode of arrangement. It may be good, or it may be bad; it may be

natural, or it may be artificial. It is natural if it is founded on such characters as shall connect together, in a system, plants that are really connected by their natural affinities. But it is artificial if it is founded on such characters as shall connect together, in a system, plants that are not really connected together by their natural affinities.

When botanists knew but few plants, the necessity of method was not much pressed upon their notice; and plants were described and arranged either wholly without method, or without any method that could be said to be founded in utility. Of this, you have examples in point in the works of Theophrastus and of Pliny—the latter proposing to himself, literally, no method whatever; and the former dividing plants into trees, shrubs, undershrubs, and herbs—a distribution founded in nature, no doubt; but by much too vague to form the ground-work of a good and scientific arrangement of plants. But as plants began to multiply in the hands of collectors, methods became indispensable, and were accordingly introduced. Yet it was not to be expected that the first methods should be models of excellence. They were but rude and incipient attempts. The principles of good arrangement had not yet been sufficiently studied; and there were, yet, no rules to direct the arranger. Hence every botanist had his own method, and methods were multiplied to excess.

The method of Villanova, published in 1508, was merely alphabetical;—a method having nothing to recommend it but the facility which it gives to the finding of any plant of which the student may already know the name. Thus plants were brought together, having no tie whatever to connect them but the identity of the first letters of the appellation by which they might happen to be designated. Another method, equally devoid of general utility, was that of arranging plants according to their several uses, as being alimentary, medicinal, or deleterious, after the example of Dioscorides. This method was adopted by Dalechamp, and is good, as we may admit, for particular purposes; but of no avail as forming the basis of a system that shall embrace the whole of the vegetable kingdom, and conduct you through a method to the name of your plant. But this could not be well accomplished except by means of characters inherent in the plant itself, sufficiently conspicuous to be easily detected, and as little liable to variation as possible. The difficulty lay in the selecting of such characters as might be the best adapted to the purpose. Hence the variety of methods that were successively introduced with a view to the establishment of a practical and well-ordered system.

Cæsalpinus has the reputation of having been the first orthodox systematist. His method of arrangement, after a primary division into trees, shrubs, undershrubs, and herbs, is founded chiefly on the fruit;

and hence he was by Linnæus denominated a Fructist. His system was published in 1583, and was unquestionably a grand step in advance beyond any thing that had preceded it.

Then followed the systems of Morison and Ray, after an interval of about a century, retaining the primary divisions of trees, shrubs, undershrubs, and herbs ; but founding the secondary divisions partly on the fruit, and partly on the corolla ; and exhibiting such a mixture of the natural and artificial methods as did not do justice to either. About the same period the systems of Rivinus and of Tournefort were published, having the primary divisions still founded on the same vague principle of trees, shrubs, undershrubs, and herbs ; and the secondary divisions mainly on the corolla—the former on the number of petals—the latter on their figure. Hence their authors obtained from Linnæus the appellation of *Corollists*. The system of Tournefort was the most beautiful, and, at the time it was published, the best existing ; nor has it been since surpassed, on the score of generic discrimination and definition ; in which respect the merit of Tournefort is so conspicuous, and his originality so very evident, as to have procured for him the distinguished title of “ The Father of this branch of botany.” Still it was liable to many objections, and still it was found to be inapplicable to new forms—or forms which the author had not himself seen.

Thus, a method capable of easy and universal application, however artificial it might happen to be, seemed still wanting to facilitate the labours of the botanist, and to give popularity to the study. This deficiency was supplied by Linnæus in the publication of his “ Sexual System” in 1735. In this system, we no longer find the vague divisions of trees, shrubs, undershrubs, and herbs ; but divisions that are more general, and more comprehensive—plants sexual or asexual—flowers conspicuous or inconspicuous. Such divisions are traits copied faithfully from nature ; but it is in the secondary divisions of his method that the system becomes artificial. Not that the author neglected the study of a natural system ; for that, he declared to be the grand and ultimate aim of all botanical research, and illustrated, in his *Fragments of a Natural Method* ; but, that botanists were not yet prepared to give, nor the world to receive, such a system. Hence this great botanist was content to devote his labours to the perfecting of his artificial system, which procured for him the title of the Prince of Botanists ; and gave him a degree of celebrity that no former botanist had ever attained to.

While Linnæus was thus employed in his individual studies, and his fame fast spreading throughout Europe, Bernard de Jussieu, the illustrious inventor of the true Natural Method, was laboriously en-

gaged in the disposing of his plants, according to that method, in the garden of Trianon, and in establishing the basis of that reputation which his nephew Antoine has since so honourably acquired; namely, that of his being the founder of a new and great school that has drawn all botanists to it, and thrown into the shade even the celebrated system of Linnæus.

The superior excellence of the method of Jussieu consists in its following closely and scrupulously the arrangements of nature. The first grand division of the Natural System, like the first grand division of the Sexual System, is founded on traits drawn from the absence or from the presence of certain reproductive organs. Yet in both systems you might find a similar division on the conservative organs also. Thus, if you take plants according to their internal structure, as being Vascular or Cellular, you have a division almost identical, whether with that of the sexual and asexual plants of Linnæus, or with that of the cotyledonous and acotyledonous plants of Jussieu. In this respect, the rival systems are pretty much upon a footing; for it is only in the secondary and minor divisions that they begin to take different routes, and to exhibit to the student their peculiar traits of character. But we do not, now, mean to enter into any detail with regard to them, having already expressed our opinion on the score of their respective merits at the article CLASSIFICATION, to which we beg to refer the reader.

MICROPYLE.—The term micropyle, lately introduced by Mirbel, is equivalent to the term Foramen, formerly introduced by Grew. It is a perforation generally visible on the exterior of the testa, and always found facing the radicle of the embryo.

MIDRIB.—The main prolongation of the foot-stalk, which extends from the base to the apex of the leaf, is the midrib.

MIGRATORY ROOT.—In the case of annual stems which are partially procumbent, it often happens that new radicles are protruded from the lower surface of the procumbent portion, and part of the stem drawn down and converted into a root every year. The new shoot issues from the apex, and progresses in the same manner; so that in the course of a few years the plant has actually changed its place, by so much as the stem has been converted into a root. Such roots are said to be migratory, and are exemplified in the genus *Iris*.

MILDEW.—Mildew is a thin and whitish coating with which the leaves of vegetables are sometimes covered, occasioning their decay and death, or injuring the health of the plant. It is frequently found on the leaves of *Tulsilago Farfara*, *Humulus Lupulus*, *Corylus Avelana*, and white and yellow Dead-nettle. It is found also on the leaves of wheat, in the shape of a glutinous exudation, particularly when the

days are hot, and the nights without dew. Willdenow says it is occasioned by the growth of a fungus of great minuteness—the *Mucor Erisyphe* of Linnæus, or by a sort of whitish slime, which some species of aphides deposit on the leaves. In cultivated crops it is said to be prevented by manuring with soot.

MODES OF VEGETABLE PROPAGATION.—As the life of the vegetable, like that of the animal, is limited to a definite period, and as a continued supply of vegetables is always wanted for the support both of man and beast, nature has taken care to institute such means as shall secure the multiplying and perpetuating of the species in all possible cases; art has invented others for the use and accommodation of man; and fancy has imagined more.

The means employed by nature are those of seeds, sporules, runners, which detach themselves from the parent plant, and become new individuals. The means employed by human art are those of the detaching of slips, layers, suckers, and of the inoculating of buds or grafts; and the means which fancy has imagined, is that of Equivocal Generation—a doctrine long and firmly believed; but now at last exploded. See DISPERSION OF SEEDS AND SPORULES; SLIPS, LAYERS, GRAFTS.

MOLASSES.—When the juice of the sugar-cane has been boiled down to a syrup, it is put to cool into sieve-like vessels placed over a cistern. The sugar crystallizes in small grains, and the impure and liquid part escapes into the cistern below. It is now called *Molasses* or *Treacle*.

MOLECULES.—The fine and filmy tissue constituting the cells and vessels, to which vegetable or animal fabrics may be reduced, was at one time believed to be the *ultima Thule* of all anatomical investigation, and the first visible substratum of all organic structure. But modern physiologists, particularly Edwards (*Sur la Vie*), seem to think that the films themselves are composed of multitudes of minute and gelatinous globules closely compacted together, and distinguishable only by the microscope. Their diameter is represented as not exceeding the $\frac{1}{8000}$ part of an inch; but their existence is by some doubted.

MONADELPHIA.—This term gives name to the sixteenth class of the sexual system of Linnæus. It implies that the filaments are all united at the bottom, but separate at the top.

MONÆCIOUS.—Plants bearing both male and female flowers on the same individual are said to be monæcious, the flowers being regarded as members of a family living in one house, as in the case of the Oak and Hazel.

MONANDRIA.—This term gives name to the first class of the Lin-

næan system, and implies that the flowers of plants belonging to it have but one stamen.

MONANDROUS.—Flowers having but a single stamen are said to be monandrous, as in *Chara*; but if they have two stamens, as in *Veronica*, they are said to be diandrous, and so on according to the number of stamens.

MONOCOTYLEDONOUS PLANTS.—Plants whose seeds have but one seed-lobe are said to be monocotyledonous, and are thus distinguished from dicotyledonous plants, whose seeds have two seed-lobes. But they are distinguished from them also in their mode of growth. In dicotyledonous plants the annual increments are circumferential; but in monocotyledonous plants the annual increments are central. They have no concentric, no divergent layers, and no medullary canal, but merely an assemblage of large and woody fibres interspersed without order in a pulp or parenchyma, soft at the centre and gradually becoming harder as it approaches the circumference. Thus they resemble dicotyledonous plants in exhibiting both a vascular tissue and a cellular tissue, consisting of organs capable of discharging duly the functions of vegetable life,—lymphatics to convey the ascending sap,—clôstres to convey the descending and elaborated juices,—tracheæ to conduct the fluid of insolation,—and medullary cells to diffuse the nervous molecules, as in the stem of *Sago farinifera*. [Dutrochet L'Agent Immed. 52.]

But the grand and peculiar feature by which they are distinguished from dicotyledons is that of the origin, and mode of the annual augmentation, of their stem. Let us take the example adduced by Defontaines. When the seed of the Palm-tree germinates, it protrudes a circular row of leaves, or of fronds, that crowns the radicle, and is succeeded in the following year by a similar row issuing from the centre or bosom of the former leaves, which ultimately die down to the base. This process is continued for four or five years successively without exhibiting as yet any traces of a stem, the remaining bases of the leaves or fronds forming in their aggregate merely a knob or bulb. At last, however, they begin to constitute by their union an incipient stem, as thick the first year as it ever is after, which in the following year is augmented in height as before, and so on in succession as long as the plant grows; the leaves always issuing from the summit and crowning the stem, which is a regular column, but decaying at the end of the year, and leaving circular marks at their points of insertion, which furrow the surface of the plant and indicate the years of its growth. [Mem. d' l' Institut. Nat. Tome I.]

MONOGYNOUS.—Flowers having but a single style are said to be monogynous, as in *Primula*; if they have two styles, as in the Grasses, they are digynous, and so on according to the number of styles.

MONOPETALOUS.—Flowers consisting of a single petal, or of several petals united, are said to be monopetalous, as in *Campanula*. When they have any other number of petals, they are designated according to that number.

MONOSEPALOUS.—If the calyx of any flower consists merely of a single piece, or sepal, or of several sepals united, it is said to be monosepalous, as in *Primula*. If it consists of any other number of sepals it is designated according to that number.

MORIN.—The colouring matter obtained from *Morus tinctoria* has been regarded by M. Chevreul as a peculiar substance, and designated by the appellation of *morin*. [Dec. Phys. Veg. i. 363.]

MORPHIA.—Morphia is an alkaloid obtained from the milky juice of *Papaver somniferum*, in which it exists in combination with meconic acid. It crystallizes in needles, or prisms, that assume a powdery appearance in the aggregate. It is soluble in alcohol, but scarcely soluble in water. Its medicinal properties seem to have been over-rated.

MORPHOLOGY.—Morphology, or the metamorphoses of parts of plants, is a doctrine yet new among phytologists, and extremely startling, it must be confessed, when presented for the first time to the contemplation of the learner. Hence the novice in morphology is apt, at first, to feel a strong repugnance to its admission; but when he has bestowed upon it a fuller consideration, and seen the beauty and simplicity of the arrangements which it implies, he begins, by degrees, to divest himself of all prejudice, and feels, at last, disposed to give it his most cordial reception; like the school-boy, who, startled at first at the miraculous metamorphoses of Ovid, which he scarcely knows what to think of, but, fascinated at the same time by the beauties of the pictorial colouring which the poet flings over the forms that “imagination bodies forth,” becomes, at last, half willing to believe them to be realities.

“In nova fert animus mutatas dicere formas

Corpora. Di cœptis,—nam vos mutâstis et illas,

Aspirate meis.”

METAMORPH. Lib. i. l.

But let not the reader be alarmed; we are not going to extend our metamorphoses to fifteen books. We will give merely a brief and hasty sketch of the leading facts on which the doctrine is founded, as taught and maintained by modern morphologists.

According to the doctrine of this new school, a plant is nothing but an axis with its leaves, which are capable of being transformed into all the other organs connected with the axis by whatever name designated—and vice versâ, the seed, perhaps, excepted. This doctrine is

thought to be involved in the *Prolepsis Plantarum* of Linnæus, though it was first exhibited under an intelligible form in the lucubrations of Goëthe.

1st. The first proof of its truth is drawn from those organs called stipulæ. They are small and leaf-like or scale-like appendages situated at the base of the petiole, one on each side, and varying much in form in different species, as awl-shaped, spear-shaped, half-arrow-shaped. In *Rosa bracteata* they are at times actually transformed into pinnate leaves, and are hence, as Dr. Lindley contends, to be regarded as leaves in miniature.

2nd. The second proof is drawn from the *bracteæ*. The bracteæ are floral leaves situated on the peduncle or common axis of the fructification, and often so near the flower as to be mistaken for its calyx. They are in fact situated between the true leaves and the calyx, having sometimes a greater resemblance to the former and sometimes to the latter. But it has been thought that they cannot be of the nature of true leaves, because they do not produce buds in their axillæ. Yet this is not universally true, for there is a bud in the axil of every bractea of the rose. In *Rosa canina* the bracteæ are dilated petioles, and in *Rosa spinosissima* they differ in nothing from leaves; and hence we infer their affinity to, or identity with, the real leaves of the plant.

3rd. The third proof is taken from the calyx, which is nothing but a leaf, or leaves a little metamorphosed. It belongs, indeed, strictly to the fructification, of which it is the first whorl; but still it does not divest itself of the character of a leaf. It even retains, for the most part, the green colour of leaves; and its sepals or divisions are in many cases not to be distinguished from the real leaves of the stem, as in that of *Mesembryanthemum barbatum*, noticed by Linnæus. But the divisions of the calyx are arranged in a whorl, says the objector, and cannot be of the nature of real leaves. Yet it may be said, in reply, that the real leaves of the plant do often come in a whorl, as in the genus *Galium*; and where they do not actually come in a whorl, they make at least an approach to it. For even alternate leaves do not, like the leaflets of winged leaves, arrange themselves always on two opposite sides, but wind round the stem spirally, so that if you but imagine their points of insertion to be closely approximated, you have a whorl still. Now, where the fructification begins, the elongation of the shoot ends, and the approximation in question takes place. Hence the parts come in a whorl, and the calyx is shown to be but a modified leaf.

4th. What is the corolla? A modified leaf also. It forms an interior and concentric whorl—the second whorl of the fructification,

consisting of several divisions called petals, not often of a green colour, it is true, but always alternating with the sepals or divisions of the calyx, from which it is, in many cases, impossible to distinguish it except by its position; as in the Liliaceæ, Orchideæ, and Scitamineæ, in which the two whorls are alike, whether in figure, colour, texture, or function; so that what is predicable of the one is predicable also of the other. Besides, there are cases in which the petals have actually reverted into sepals. In a flower of *Campanula Rapunculus* seen by Röper the corolla had actually degenerated into five green leaves like those of the calyx. [Lindley, Introd. 514.] Thus the petals are merely modified leaves.

5th. Within the whorl of the corolla comes that of the stamens. These form the third whorl of the fructification, and consist of one or more rows. If of a single row, they are equal in number to the divisions of the corolla, with which they, in this case, alternate. But if not, and if they face the divisions of the corolla, their outer row is supposed to be wanting, and a second row to be developed in its stead, as in the Primulaceæ, in which you may easily distinguish the several petals, though united, by their margins, with the stamens facing them. The same thing may be said of *Narcissus*, the cup of which is formed of the three stamens of the first row, now petaloid and united by their margins. They are proved to be modified stamens by the tendency of double *Narcissi* to produce abortive anthers on the margin of the lobes of the cup. But if the stamens thus approach to petals, so do the petals also approach to stamens, the base becoming a filament, and the apex a degenerate anther. Hence, if a petal is a modified leaf, so is a stamen. But the truth is that stamens are sometimes actually converted into green leaves. Röper saw this in the stamens of *Campanula Rapunculus*, and M. Du Petit Thouars, in the stamens of *Brassica Napus*. [Lind. Introd. 515.]

6th. The last and central organ of the flower is the pistillum. Take it in its most simple state, as in *Pisum*, in which it is an ovary consisting of two valves with two opposite seams, to one of which only the seeds are attached, the style being an elongation of the other. Now if this ovarium is compared with a young leaflet unfolded, it will be evident that the ovule-bearing suture answers to the two margins united, the style-bearing suture to the midrib or costa, and the style itself to the mucro or apex. Further, the costa, or suture without ovula, is always external with respect to the axis of fructification, as the costa of a leaf would be if folded up and terminating the fructification. Finally, it is not at all a rare thing to find pistilla converted into leaves or petals, as in double *Narcissi*, and the double Cherry. [Smith's Introd. 275.] Hence we can scarcely hesitate to conclude

that the pistil, like the other parts of the flower, is reducible to leaf; and that each division of the ovary, if compound, is, as it were, a separate leaf or pod.

But if all the parts of the fructification are convertible into one another, and ultimately into leaves, then it will follow that a flower-bud is nothing different in its origin from a leaf-bud; and this is what the morphologists maintain. But, what is it that makes the leaf-bud, at any time, to deviate from its usual mode of developement, and to protrude a fruit-spur, peduncle, and flower, instead of a woody stem? what is it that gives to the interior parts of the flower a tendency to change their form and function, and to revert again to leaves? This is the riddle that cannot be expounded; the problem that cannot be solved; the mystery of modern morphology—that no one can unveil. Yet we are compelled to receive the facts, whether we can account for them or not. But the processes in question are evidently in keeping with a variety of other processes whether of the animal or vegetable kingdom. Thus from the blood are extracted all the peculiar juices and secretions of the animal body; and from the sap duly elaborated, all the peculiar juices and secretions of the vegetable body; so that we need not be so much surprised if we find leaves convertible into all the different organs above enumerated, by means of causes occurring and originating in the regular order of nature, though not yet cognizable to human ken.

Yet Morphologists are free to speculate, and to trace out causes as far as they are traceable. The general rule is, that the floral whorls of plants have a symmetrical arrangement around the axis, and that the parts of each separate whorl alternate with those of the contiguous whorls; and though certain species, in their arrangement and alternation, are almost always irregular, yet certain individuals from among them are occasionally found to assume a regular structure, by the developement of parts formerly latent. This is exemplified in the case of *Linaria vulgaris*, or Snap-Dragon. The flower is generally *personate*, the corolla monopetalous, with two large lobes closed in front, and presenting the appearance of the snout of a calf, the upper portion extending backwards in the form of a spur, the stamens in two pairs of unequal length, the calyx divided into five segments, indicating the adhesion of five sepals, and the pistil a two-celled capsule having the seeds on a central *placenta*. Now all this is highly irregular. But there is a variety of this plant, namely, *Linaria Peloria*, in which the return to symmetry is palpable, in its being furnished with a five-toothed monosepalous calyx, a monopetalous corolla, composed of five adhering petals, narrowing in front, and elongated into five spurs behind, and its parts alternating with those of the calyx; five stamens

of equal length, alternating with the parts of the corolla; but a pistil which is composed of only two carpels, as in the irregular flower. This the morphologists regard as the normal developement of the species, and account for the deviations from it which the species usually exhibits, as well as for all such deviations from normal structure, by attributing them to one or other of the three following causes—abortion—that is, where the organ is supposed to lie altogether dormant;—degeneration—that is, where the organ does not perhaps lie altogether dormant; but is only not fully developed; and adhesion, or the want of it—that is, where the several parts of a whorl have unduly adhered, or unduly split. [Henslow's Descrip. Bot. Cab. Cyclop.] But what is the cause of the causes here assigned? Here we are compelled to stop.

M. Decandolle admits the facts of the Morphologists, but offers no solution, or seems rather to regard all solution as impracticable in the present state of our knowledge. But he classes under the head of metamorphoses also, certain other accidental changes that occur in the parts of vegetables, such as an enlargement of one organ at the expense of another; the change from a succulent to a scariose consistence, which leaves or bractes often undergo; the flattening of the stem or branches, and the production of thorns where branches should be. [Phys. Veg. ii. 771.] In this he is followed by Dr. Lindley, who presents us with a series of metamorphoses, which he calls irregular—such as changes effected on roots or tubers, or on the stem, leaf, or flower,—by domestication, cultivation, or peculiarity of station, as on the roots of turnips or potatoes; or on the stem of *Chou moellier*, or on the leaves of curled parsley; or on flowers changing from one colour to another. But here, the root, stem, or leaf, though modified, is still a root, stem, or leaf. It has not been changed into an organ different both in form and function from that of the organ which it was before; as when a pistil is converted into a leaf. It has been modified in some of its more visible properties merely, and is still the same organ that it was at first. There has, in fact, been no thorough change, and on this account, if we were called upon to express our own opinion, we would say that such changes should be called *anomalies*—not metamorphoses.

Still, there are other phenomena occurring in the vegetable kingdom, which, if they are not deceptions, seem well entitled to the designation of Metamorphoses, and which we ought, as I think, to include in our list. One of the most mysterious of such phenomena, is the change by which certain living entities seem to pass from the animal to the vegetable state, or *vice versâ*; without decomposition, or apparent disorganization of fabric. Professor Nees Von Esenbeck was the first to publish his opinions on this subject in 1814. His observations

were made chiefly upon the filamentous Algæ, particularly the Oscillatoriæ. The animal state is inferred from the spontaneous movements of the individual—the vegetable state from its immobility. A monad or active molecule issues from the summit of the filament, and frolics in the fluid in which the plant vegetates. Ultimately a period arrives in which a complete metamorphose ensues, the moving monad being gradually converted into a motionless vegetable like *Daphne in Lauram*, or *Narcissus in Florem*.

“ In frondem crines, in ramos brachia crescunt;
 Pes, modo tam velox, pigris radicibus hæret;
 Ora cacumen obit.”

OVID. MET. Lib. i.

The professor regards the minute red globules of *Protococcus nivalis*, as being the vegetable state of bodies that had previously enjoyed an animal existence, of, perhaps, an atmospheric origin. But Agardh, Bauer, and Greville, do not say that they perceived any traces of animality in this substance. Hence the matter remains doubtful; though the movements of the Oscillatoriæ are very generally regarded as being decidedly animal.

The latest and most decisive observations on this subject have been made by M. Franz Unger. In 1828 he traced the metamorphose of the globules of the *Ectosperma clavata* of Vaucher, now *Vaucheria clavata*, from the animal to the vegetable state, and back again, with a degree of patience and perseverance which seemed to have left nothing undone, to establish the fact in question. The globules were of a green colour, and were found to issue from the summits of the *ramuli*. Many of them swam freely in the water of the vase in which the plant was placed, moving at their option in any direction, or stopping, and again putting themselves in motion like all other *infusoria*. After the space of an hour, their animality began to exhibit symptoms of being on the wane, and was very soon after extinguished in their death. Some of them retained their dark-green colour, and kept still moving; while others had become tumid, motionless, and transparent. They were now vegetable monads in a state of germination [Loud. Mag. of Nat. Hist. vol. i. 305], each protruding an appendage by which in a day or two it became fixed, and afterwards protruding a stem, which continued to elongate till about the eleventh day, when the animal globule began again to make its appearance at the summit of the principal branch, and the cycle of events to be repeated as before. We do not find that botanists are yet prepared to receive these alleged metamorphoses as facts that may be relied on.

MOSESSES.—The mosses—*musci*, are a tribe of imperfect plants, of a small and diminutive size, consisting merely of a root surmounted with a tuft of minute leaves, from the centre of which the fructification

springs; but furnished for the most part with a stem and branches on which the leaves are closely imbricated. Their most favourite stations are bleak and barren soils, such as mountains, heaths, woods, where they are found not only rooted in the earth, but attached also to the roots and trunks of trees, and even to the bare and flinty rock, or immersed in bogs and ditches, or floating, though fixed by the roots, in streams of running water.

“Ego laudo ruris amæni

Rivos, et musco circumlita saxa.”

HOR. Lib. I. Epist. x.

As mosses affect the most barren soils, so they thrive best also in the coldest and wettest seasons. In the drought of summer they languish, but in the temperature of autumn they recruit; and many of them, even in the chilling colds of winter, protrude their blossom, and mature their fruit. From the extreme minuteness of their parts they are apt to be overlooked by the superficial observer, or disregarded by the novice in botany, who is attracted, perhaps, only by what is specious in the plant or flower; but who, when the desire of botanical knowledge shall have inspired him with a relish for microscopical observation, will find the study of the mosses to be no less interesting than that of the most perfect plants, and the form and texture of their parts to be no less beautiful and elegant than that of the most gaudy flowers.

The root consists generally of a number of small and slender fibres, closely matted together, as in *Tetraphis viridula*; smooth as in most examples, or covered with a fine and velvety down, of a dark or rusty colour, as in *Bryum ligulatum*—the most beautiful, or one of the most beautiful of all British mosses. Some mosses are altogether stemless, as in the case of *Phascum muticum*; others are nearly stemless, and all are diminutive compared with herbs in general, few of them attaining to, and still fewer of them exceeding, a foot in height. But where a stem exists, it is generally, like the root, weak and slender, as in *Hypnum serpens*, though sometimes stiff and shrubby, as in *Hypnum alopecurum*. The branches are in their structure similar to that of the stem, and are arranged regularly, as in *Hypnum proliferum*, or irregularly, as in *Hypnum riparium*. The leaves are exceedingly minute, but are at the same time exceedingly elegant. The most frequent forms are the linear, the lancolate, the oval, the concave. They are always, as I believe, sessile, though often decurrent, or sheathing, with the margin beautifully waved. Some are entirely smooth, as in *Hypnum splendens*; others are beautifully dotted, or reticulated, or streaked, as in *Hypnum striatum*. The *Buxbaumia aphylla* of Schmidel was thought to be wholly leafless till Dr. Brown at last detected its leaves. [Lin. Trans.

vol. xii.] Besides the leaves proper to the species in general, plants producing barren flowers are furnished with a peculiar sort of leaves which are crowded together at the extremities of the branch or stem so as to form terminating stars, by expanding in the form of rays, in which case they are larger and more elegant than the rest, as in *Politrichum commune*; or so as to form a sort of terminating bud, in which case they are smaller than the rest, as in the *Hypnum*s.

The fructification of the mosses, though extremely elegant in its structure, is yet, at the same time, so extremely minute as to be but seldom noticed except by botanists; by whom also it seems to have been long overlooked, or, at the most, but imperfectly investigated. The ancients regarded the mosses as a tribe of plants originating in the putrefaction of other vegetables, and consequently as producing neither flower nor fruit. The earlier botanists of modern times seem to have regarded them in the same light. Even the great and illustrious Tournefort classes them along with mushrooms and sea-weed, under the title of *Aspermæ*, or plants without seed. But this doctrine began to give way along with the doctrine of equivocal generation. Perhaps the first hint leading to a correct view of the subject, was that given by Dillenius, in the Appendix to his Catalogue of Plants, growing in the neighbourhood of Gisse [Gissæ, 1719, 8vo.], in which he regards the mosses as being indeed without seed, but furnished with little heads containing a powder by which the terminating leaves were rendered capable of germination.

But Micheli, inspector of the botanic garden at Florence, seems to have been the first of all modern botanists who obtained a complete view of the fructification of the mosses, as consisting of a sexual apparatus, which he not only describes, but figures [Nov. Plant. Gen. Tab. 59. 1729], though he seems at the same time to have been wholly ignorant of the respective functions of the organs which he was describing, having mistaken the barren for the fertile flower; as well as perhaps altogether unacquainted with the true and legitimate doctrine of the sexes of plants. Dillenius, who again resumed the subject in his *Historia Muscorum*, published at Oxford in 1741, though he describes the flowers of the mosses with great accuracy, and even with a view to sex, yet by mistaking the barren for the fertile flower, left the subject involved in the same obscurity in which he found it. Linnæus, by adopting the opinions, and consequently the errors, of Dillenius, did the same thing. But Hill was lucky enough to refute the opinions of both, in proving the capsula of the former,—that is, the anthera of the latter,—being with them terms synonymous,—terms equivalent to pollen-bag,—to be a real seed-vessel, by means

of the experiment of sowing the powdery substance contained in it, and obtaining as the result a crop of young mosses. [Hist. of Plants, chap. xlv.] Yet the service which Hill thus rendered to the cause of botany is scarcely ever heard of, owing, as I suppose, to the unavoidable disrepute into which his work has fallen. He failed, however, in discovering the real anthers, erroneously believing them to be what he called the rays of the corona. Thus the most profound mystery still enveloped the subject, inducing a degree of botanical scepticism inconsistent with impartial research, which discovered itself particularly in the case of Necker, urging him to exclaim rather too hastily that whatever had been, or might in future be said of the fructification of the mosses, he was determined to regard as a fiction, or dream.

In this stage of the enquiry the celebrated Hedwig, born as it was said to abolish cryptogamy, perceiving the disorder and obscurity in which every thing lay relative to the fructification of the mosses, undertook the arduous but indispensable task of investigating every thing *ab initio*. This he accordingly did with a degree of caution, and scrupulosity, and patience, never yet surpassed, taking no fact upon trust, and employing glasses of a higher magnifying power than any preceding botanist; so that in the end he succeeded in obtaining a clear and complete view of the whole subject, disencumbering it of the rubbish with which it had been so long clogged, and presenting to the cryptogamist a superstructure not the offspring of his own fancy, but the image of nature.

According to Hedwig, the barren flowers of the mosses are the stars, disks, or buds, that terminate the branches and nestle in the bosom of the leaves. In their exterior they consist of leaves or scales, larger or more elegant than the other leaves of the plant, but never terminating in hairs. These he regards as constituting the calyx. In the interior they consist of a number of thread-shaped and succulent substances, issuing from between the leaves or occupying the centre. These he regards as stamens, furnished with an anther that bursts open when ripe, and discharges a pollen; which phenomenon may be seen by means of placing a stamen fully ripe upon the stage of a high magnifier, and wetting it with a drop of water. The summit of the anther bursts open, and the pollen explodes. [Fund. Hist. Nat. Musc. chap. viii.]

The fertile flowers are of a most singularly curious construction. They consist of an urn-shaped capsule surmounted with a calyptra or veil, in the form of an extinguisher, and invested at the base with a membrane called a *perichæcium*, or fence. Some writers have called the fence a calyx; but we believe there is no unanimity among bo-

tanists on this point. The urn is sessile, as in *Phascum muticum*, or surmounted on a pedicle, as in *Polytrichum commune*. When the veil falls off, or is forcibly torn off, its mouth appears, covered with a lid or *operculum*; and when the lid falls, the mouth is found to be furnished with one or more rows of fine and tooth-like substances called the *peristomium*, or fringe. In their ripened state they assume a tinge of brown, red, or yellow, as does also the lip of the urn or capsule in which they are contained. Within the urn, and in the direction of its longitudinal axis, there is situated a slender and cylindrical substance, which seems to be a prolongation of the pedicle, passing through the whole extent of the urn, and perforating both lid and veil. This organ is designated by the appellation of the *column*, and its summit, which forms the apex of the flower, is regarded by Hedwig as the style of the mosses. The cavity of the urn and column is filled with multitudes of spherical granules, becoming ultimately a fine powder, green, brown, or yellow, which in the opinion of Hedwig are seeds, and from which he obtained, as in the experiment of Hill, a crop of young mosses in all respects similar to the parent plants. Hence, if Hedwig's theory of the sexuality of mosses should be even erroneous, as it is thought by many to be, it establishes at least one fact,—namely, that the granules of the urn or column are capable of re-producing the species; so that if they are not seeds, they are, at any rate, *sporules*.

There are also other writers who have done much to illustrate this interesting department of cryptogamy, of whom I may specify Schreber, Swartz, and Bridel on the continent, with Dickson, Turner, and Hooker in this country,—the former chiefly by dried specimens, and the two latter by verbal description and by figures. Hooker rejects the sexual theory of Hedwig, though it had received considerable countenance from Dr. Brown, in a paper which the reader will find in the tenth volume of the Linnæan Transactions. But whether he has altered or modified his opinion since the publication of that paper, we cannot say. Mr. Valentine, a Fellow of the Linnæan Society, has given us a paper, also, in the last published No. of the Transactions [Vol. XVII. Pt. iv.], in which, after a great deal of minute dissection and investigation, he thinks himself entitled to conclude that the sexual theory of Hedwig is untenable in all its dimensions; and that the mosses, instead of being furnished with true seeds capable of re-producing the species, are not even furnished with a sexual apparatus; the alleged seeds being merely masses of sporules, and the alleged anthers, or the globules which they contain, being merely a species of gems. Whether or not this conclusion is sufficiently well founded to set the question at rest for the future, time will show.

MUCILAGE.—A species of gum found chiefly in bulbous plants. See the article GUM.

MURIATES.—The muriate, or hydrochlorate, of potass, is often found in the ashes of vegetables, particularly of their green and herbaceous parts, as the root of *Polygala Senega*, the haulm of beans, the straw of wheat, and the leaves of tobacco. Muriate of soda is also to be found in the ashes of many vegetables, but chiefly of marine plants, as *Zostera*, *Salsola*, *Salicornia*, and the Fuci.

MUTILATED FLOWERS.—If there is a defect in any flower by the absence of any of those parts which are common to the species, as in the flowers of *Campanula pentagonia*, in which the corolla is often wanting, the flower is said to be mutilated.

MYRICINE.—Wax of myrtle is now found to be composed of two substances,—cerine and myricine,—though they differ merely in their degree of fusibility and solubility in alcohol. They are separated by the same processes as the stearine and oleine of fat. The myricine represents the stearine, and the cerine represents the oleine. [Raspail. Chim. Org.]

MYRRH.—This substance is a Gum-resin, the produce, as it is thought, of a species of *Mimosa*. It is obtained in the form of tears, of a yellow colour, a strong odour, and a bitter taste. It has the reputation of being astringent and stomachic; but let patients having delicate lungs refrain from the use of it altogether. It is extremely apt to induce hemorrhage. *Expertus loquor*.

NAKED FRUIT.—If the fruit when it falls from the herb or tree is left without any extraneous or supernumerary appendage, as in the cherry, apricot, and currant, it is said to be naked. But if it is invested by the calyx, as in hollyhock, or by the corolline valves, as in the grasses, or by the receptacle, as in the fig, it is then said to be coated; and if it is invested but partially, it is then said to be veiled, as in the case of the hazel-nut, which is veiled by the calyx.

NAKED SEEDS.—Seeds destitute of a conspicuous pericarp are said to be naked, or have hitherto been said to be so; as in the case of the Labiatae, which still show traces of a pericarp. But seeds that are truly naked show no traces of a pericarp at all, the very ovula being naked, as in the *Coniferæ* and *Cycadeæ*.

NARCOTINE.—Narcotine, like morphia, is a substance obtainable from the milky juice of the *Papaver somniferum*, but without manifesting the properties whether of an acid or an alkali. Some chemists regard it as possessing peculiarly the stimulating virtues of opium, while they regard morphia as possessing peculiarly the sedative virtues. Yet in this there seems to be some room for doubt; for

either of them taken in large doses will produce stupor and ultimately death. Many plants are capable of furnishing narcotine besides *Papaver somniferum*, particularly those called *Luridæ*.

“*Lurida terribiles miscent aconita novercæ.*”

OVID. MET. Lib. i. 147.

NATURALIZATION.—Naturalization is defined by M. Decandolle to be the act of transporting or transferring a plant into a country different from that in which it originally grew. Yet this seems to us to imply nothing more than merely the voyage across the ocean, or the journey, as it may be, overland, by which the plant was transported into this new country. Surely it is not yet naturalized. Can it be said to be naturalized till it has been planted, and given proof that it is satisfied with its newly adopted country? If its new habitation is pretty much similar to the habitation which it has left, its naturalization is soon effected; but if it is considerably different, particularly on the score of temperature, its naturalization may very possibly be altogether impracticable; or if it is practicable, it can be only through means of the process of acclimation, which signifies the accustoming of a plant to a temperature different from that of the country in which it originally grew; the possibility of which M. Decandolle seems scarcely to admit. [Phys. Veg. iii. 112.] But with the fact before our eyes that plants from warmer climates, as *Aucuba Japonica*, and *Peonio Moutan*, do ultimately become accustomed to colder climates, by occupying, first the hot-house, and then the green-house, preparatory to their being exposed to the open air, how can we refuse to admit the possibility of acclimation?

NECTARY.—The nectary is an appendage of the flower, attached for the most part to the corolla, and secreting, or containing, a honied juice. This appendage does not seem to have attracted the notice of the botanists of antiquity. The earliest notice of it that I have ever met with is that of Malpighi, who, in speaking of the leaves of flowers, that is, the petals, admires the singular and curious contrivance of nature in furnishing them with an organ, which he compares to the cavity of a shell, in which there is deposited a honey: “*Mirabile est quod natura quasi conchas in florum foliis excitavit quibus mel custodiret.*” [Anat. Plant. 47.]

But as botanists began to be more minute in their investigations, the nectary began also to be more a subject of remark. It was next noticed and described both by Tournefort and Vaillant, at least as it occurs in some particular species; but it was not designated by any particular name, which it was, perhaps, not thought of sufficient importance to merit. But Linnæus, who well knew how to appreciate its

real value, as furnishing the botanist with one of the best possible characters of generic discrimination, soon saw the necessity of giving it a name, and applied to it the very appropriate appellation of *nectarium*—the nectary, or honey-cup, from *nectar*, the drink of the Gods.

“ Illum ego lucidas
Inire sedes, ducere *nectaris*
Succos, et ascribi quietis
Ordinibus, patiar, Deorum.”—HOR. Lib. III. Ode iii.

Yet no term he has introduced has been more severely censured by contemporary and succeeding botanists, upon the score of its having been made to include a variety of minute parts or organs not certainly known to discharge the function of which it is descriptive. But neither can it be positively said that they do not discharge it; and it is not necessary that a botanical term should be always descriptive of function. Yet where the function of the appendage is doubtful, the describer is unquestionably at liberty to designate it by a different appellation if he pleases; and this is what botanists do in fact.

Of appendages called nectaries, and known to secrete honey, the principal species are glands, cavities, and pores. The floral glands of *Cheiranthus*, *Brussica*, *Sinapis*, and many other cruciform flowers, situated within the shorter stamens, are indubitably secretory organs, and the fluid which they secrete is nectarous. The cavities observable in the petals of *Ranunculus*, situated immediately above the claw, are also secretory organs, and the fluid secreted is nectarous. The pores observable in the petals of a variety of flowers, as in those of *Hyacinthus orientalis*, are said also to be secretory organs, the secreted fluid being nectarous. To these may be added the fleshy or scale-like substances which surround the ovary in most plants of the family of the *Proteaceæ*, as characterized by Dr. Brown in his learned and elaborate paper on that natural order. [Lin. Trans. Vol. X. Pt. i.]

Of appendages called nectaries, and known to contain honey, the principal species are as follows:—The *tube*, being a tubular process issuing from the petal, as in *Helianthus* and *Pelargonium*; or the tubular part of a monopetalous corolla. The *spur*, being a spur-shaped process issuing immediately from the corolla, as in *Orchis*; or supported upon a proper pedicle, as in *Aconitum*. The *slipper*, being a petaloid process issuing from the corolla, and inflated in the form of a slipper, as in *Cypripedium*.

Of appendages presumed, from analogy, to be nectaries, but not certainly known to be so, the following species are the most distinguished. 1. The *vault*, being a vaulted process, or processes, at the orifice of a monopetalous corolla, enclosing and covering the stamens,

as in Common Comfrey and Alkanet. 2. The *beard*, being a tuft of fine hairs or bristles, issuing from the calyx or corolla, as in *Thymus*, *Iris*, *Periploca*. 3. The *corona*, being a petaloid process of one or more pieces, situated within the circle of the corolla, in the form of a little cup or crown, as in *Narcissus*. Modern botanists regard it as being composed of metamorphosed stamens. 4. *Threads*, being processes issuing from the receptacle of the flower, and resembling the filaments of the stamens, as in the Passion-flower. Perhaps they also should be regarded as abortive or metamorphosed stamens. 5. *Scales*, being the minute, scale-like, and often membranaceous substances found in the flowers of the Grasses.

NERVES.—The ramifications of the fibres of the petiole, as prolonged throughout the expansion of the leaf, are very often spoken of as being the nerves of the leaf; though it cannot be said that they are at all analogous, in their function, to the nerves of animals.

NERVIMOTILITY.—It too often happens, says M. Dutrochet, that zoologists know nothing of botany, and botanists nothing of zoology. Yet the study of both should be sedulously cultivated; for doubtless they shed a mutual light on each other. They do so particularly with regard to the movements which each exhibits respectively. The limbs of animals, in general, are furnished with joints, and moved by means of muscles, which are put into motion by the agency of nerves, which are themselves excited by the agency of external *stimuli*. But plants have neither nerves, nor muscles, nor moveable joints, and yet the parts of many of them have spontaneous, and even visible motion. Still it is merely a bending of such parts as are soft and flexible; the organic tissue undergoing an interior movement that causes the flexion, and the recovery from flexion. By what means then is this movement effected? M. Dutrochet undertakes to show, that the movements of plants, like the movements of animals, are, in fact, effected through the instrumentality of nervous matter, and of muscular force, though not under the palpable modification either of nerves or of muscles. Hence the phenomenon may still be said to originate in the principle of *Nervimotility*.

The nervous system of animals of the higher class—the Vertebrata—is essentially composed of groups of conglomerated globules cognizable by the microscope, according to the observations of the most celebrated anatomists, and microscopic observers, as Lewenhoeck, Prochaska, Home, Bauer, the Wensels, Edwards. The globules seem to be cells of extreme minuteness, containing medullary or nervous matter coagulable by heat and acids. In their aggregate they constitute the brain, from which there proceeds a spinal or vertebral marrow, sending out numerous nerves to the senses, and to the muscles of the

limbs ; and to which there is further appended the ganglionic system with its connecting cords and nerves, which seem in their ultimate divisions to be fine and slender tubes filled with a diaphanous fluid. The nervous system of the lower classes appears to be wholly ganglionic. This is well shown in the case of the Molluscous Gasteropodes. The brain, or first ganglion, consists of two hemispheres, from which two cords issue embracing the œsophagus, and uniting again to form a ganglion, and so on in succession till the series is complete. The nervous system of the lowest classes is merely molecular. The Polypi and infusory animalcules are presumed to have no nerves. But they have granulations interspersed throughout their soft and gelatinous mass which resemble the globules now described, and which M. Dutrochet regards as being undoubtedly their nervous organs.

The muscular system of the higher orders of animals is composed of bundles of muscular fibres, and a single muscle is composed of many bundles. They have the property of contracting or of shortening their length by drawing themselves up into wrinkles, or transverse folds. Hence their peculiar fitness for giving motion to the limbs in which they are inserted. It is difficult to get at the primary fibriles, but they are represented by modern physiologists as being ultimately reducible to globules, similar in appearance to the nervous globules, and not to be distinguished from them except by chemical tests ; the muscular globules being soluble in acids, but insoluble in alkalies ; and the nervous globules being soluble in alkalies, but insoluble in acids. In the lower orders of animals you have merely rows of muscular globules ; yet they are equally available to the purposes of muscular function with the fibres themselves ; the former shrinking by condensation, the latter by incurvation.

Such is a brief view of the Nervimotility of animals, when the impression from without, or the stimulus from within, impels or excites the organs. Let us now see what proofs M. Dutrochet adduces in favour of vegetable nervimotility. His first observations were confined chiefly to the movements of the leaflets and petiole of the sensitive plant, which are known to almost every body, as resulting from the slightest touch of the finger, or other instrument applied to them. In this case he found that the tumour at the base of the petiole is the seat of the moving power ; for if that is cut away the motion ceases. The upper part of the tumour pulls the petiole up, and the lower part of it pulls the petiole down. This was ascertained by making the experiment, first, with a petiole having the one half of the tumour cut off, and then with a petiole having the other half cut off. Hence the one half of the tumour is the cause of flexion, and the other half the cause of recovery, as in the antagonist, or flexor and tensor muscles

of animals. Now the tumours of the Mimosa, in the language of Dutrochet, are composed partly of nervous globules, known to be such by their being soluble in alkalies; and partly of rows of muscular globules, known to be such by their being soluble in acids.

Thus, plants, according to Dutrochet, without having real nerves, have the elements of nerves, and, without having real muscles, have the elements of muscles; and their movements are effected, as in the zoophytes and infusory animalcules, if Ehrenberg's discoveries have not negatived the comparison. After a contraction there comes a relaxation—in animals often rapidly; in plants more slowly; except in *Hedysarum gyrans*, in which it is rather quick, or at least not very slow, and in which it is perpetual, as it is in the filaments of the Oscillatorias. Yet you may have both flexion and recovery without either bunch or tumour. If the scape of a Daffodil is bent down by snow or frost, it recovers itself again when the temperature becomes more mild; or if the stem of a balsam sinks down for lack of moisture till it touches the earth, it recovers itself again, upon the application of plenty of moisture. Still, upon the principles of Dutrochet, the phenomenon is owing to the nervimotility of the plant. For where he has not tumours he attaches the globules to his *Vaisseaux corpusculifères*, and makes them efficient, even there, to the purposes of vegetable movement.

Thus we have endeavoured to exhibit a brief and correct view of M. Dutrochet's theory of nervimotility. We do not know that it has been adopted by any botanist or physiologist of distinction; but as the contractility in question is evidently vital, it seems to demand and to imply the agency of the causes to which M. Dutrochet attributes it,—not as involving feeling, but merely ganglionic action. [Observ. sur les Mouv. de la Sensit.]

NICOTINE.—A peculiar principle obtained by distillation from tobacco. It is a colourless and transparent fluid having the odour of tobacco, with a greater degree of pungency, and leaving a sharp and biting impression on the tongue. It neutralizes the mineral and vegetable acids, and forms peculiar salts. It seems to be composed of carbon, hydrogen, oxygen, and nitrogen. [Phil. Mag. Nov. 1835.]

NITRATE OF LIME.—This salt is said to have been found in Borage, the Nettle, the Sun-flower, and Pellitory of the Wall.

NITROGEN.—Nitrogen or azote is one of the component elements of atmospheric air, amounting to about $\frac{4}{5}$ of its bulk. It cannot be said to be a vegetable food, if presented to the plant in a state of purity: on the contrary, it operates rather as a poison. Yet many plants are found by analysis to contain a certain proportion of it; such as Cruciform plants in general, but particularly mushrooms, to which we ought

perhaps to ascribe the deleterious properties which a variety of them is known to possess. How does the nitrogen enter the plant? It may enter the root in solution with animal manures, which are known to contain nitrogen; for it has been observed that the more a field is manured with animal substances, the more of nitrogen is found in the crop. [Hermstædt.] Or it may enter the leaf, or general tissue, as a component part of the atmospheric air, which some plants may have the capacity of inhaling entire.

NOMENCLATURE.—The plants that first received names were doubtless such as are “good for food, or pleasant to the eye,” or, in some way or other, useful or injurious to man. There were yet no rules of nomenclature; though the names imposed upon them were probably descriptive. The first writers in botany were content to adopt the nomenclature that was then in use;—that is, the vulgar names by which the plants described were known in the countries in which they grew. Hence the *Σπαρτιον* and *Αγρωστις* of Theophrastus, and the *Plantago* and *Lactuca* of Pliny. Upon this principle every individual had its own proper name, which did tolerably well while the plants yet known were but few. But when the number of known plants had much increased, it was found to be too great a trial of memory to burden it with a separate name for each individual plant. Hence the various attempts that were made to abridge the labour of the student, and to improve the nomenclature of botany, particularly from the time of the memorable event of the revival of letters. But, instead of ending in a nomenclature calculated to designate the species clearly and concisely, it ended only in the introduction of specific descriptions added to generic names, so long and so intricate as to threaten destruction to the very science itself, from the immense mass of rubbish with which it was encumbered. Hence nothing was done that merited, or met with, the cordial reception of botanists till the publication of the celebrated canons of Linnæus in 1737. The following are a few of the leading canons, which will satisfy the reader of the soundness of the principle on which the Linnæan nomenclature is founded.

1st. The name of every plant shall consist of two terms,—the first indicating the genus; the second, the species.

2nd. All plants of the same genus shall have the same generic name.

3rd. All plants distinct in genus shall have distinct generic names.

4th. Every generic name must be single.

5th. All generic names shall be either of Greek or of Latin origin; but no compound, half Greek and half Latin, shall be admitted.

6th. Generic names expressive of the essential character or habit of the plant are the best.

7th. The names found in the ancient classics are to be respected particularly the names of great promoters of the science; and new names may be given to new genera upon this principle.

8th. It belongs to him who establishes a new genus to give a name to it.

Such are the leading canons with regard to generic names; and the imposing of specific names is subject to the same rules. The specific name is to follow the generic name; and by this juxtaposition the nomenclature of the plant is complete. The names of classes and orders are subject to the same rules as those of genera; but they are not to be prefixed to, nor added after, the names of individual plants. [Phil. Bot. Differentia.]

Besides the nomenclature of classes, genera, and species, there is also a nomenclature that relates to the terms employed to designate the more general departments of botany, whether descriptive or physiological. French botanists, and after them some English botanists, seem peculiarly fond of introducing Greek compounds for this purpose; and if the language in which a writer expresses himself affords no suitable or appropriate term, the introduction of them is worthy of commendation. But where that is not the case, the use of them seems to us to be but an idle display of a little learning. Such are the terms, Organography, Phytography, Taxonomy, Glossology; which, as we have terms in our own language, already, that are about as good, we do not regard as an acquisition of any value. In what respect is Taxonomy better than Classification, or Organography better than Structure?

NUCLEUS OF THE SEED.—The *nucleus* is that part of the ripened seed which is contained within the proper integuments, consisting of the albumen, with the *vitellus*, when present, and embryo.

NUTS.—Individual seeds contained in a bony pericarp, invested with a leathery sarcocarp, or lodged in a succulent torus, as in the Strawberry, are called nuts. The fruits usually called nuts are rather glands, or acorns.

NUT-SHELL.—The nut-shell, or putamen, is a pericarp of a hard and bony, though sometimes of a leathery texture, not opening spontaneously, or, if opening, not into more than two valves. It is exemplified in the Filbert and Chestnut.

NUTATION.—It was observed in early times that some flowers not only expand during the light of day, but incline also towards the sun, and follow his course; looking towards the east in the morning, towards the south at noon, and towards the west in the evening; and again returning in the night to their former position in the morning. Such flowers were called *Heliotropes*, on account of their following

the course of the sun, and the movement which they thus exhibit is denominated their *Nutation*. It was known to the ancients long before they had made any considerable progress in botany, and had been, even, interwoven into their mythology, under a belief that it had originated in one of the metamorphoses of early times. Clytie, inconsolable for the loss of the affections of Sol, by whom she had been formerly beloved, and of whom she was still enamoured, is represented as brooding over her griefs in silence and in solitude; where, refusing all sustenance, and seated upon the cold ground, with her eyes invariably fixed on the sun during the day, and watching for his return during the night, she is at length transformed into a flower, retaining, as much as a flower can retain it, the same unaltered attachment to the Sun.

“Sub Jove, nocte dieque,
 Sidit humo nuda, nudis incompta capillis.
 Perque novem luces expers undæque cibique
 Rore mero, lacrymisque suis jejunia pavit.
 Nec se movit humo; tantum spectabat euntis
 Ora Dei; vultus suos flectebat ad illum.
 Membra ferunt hæsisse solo; partemque coloris,
 Luridus exsanguis pallor convertit in herbas.
 Est in parte rubor; *violæque simillimus ora*
Flos tegit. Illa suum, quamvis radice tenetur,
 Vertitur ad Solem; mutataque servat amorem.”

OVID. MET. Lib. iv. 250.

Here we may observe that the flower alluded to by Ovid cannot be the *Heliotropium* of the moderns, because he describes it as resembling the violet; neither can it be the sun-flower of the moderns, which is a native of America, and could not have been known to Ovid; so that the true *Heliotropium* of the ancients is, perhaps, not yet ascertained. Further, Bonnet has remarked that the ripe ears of corn, which bend down with weight of grain, scarcely ever incline to the north, but always less or more to the south; of the accuracy of which remark any one may easily satisfy himself by looking at a field of wheat ready for the sickle; he will find the whole mass of ears nodding, as if with one consent, to the south.

NUTRITION.—This term designates the ensemble of the functions by which living beings are enabled to take up and assimilate the nourishment necessary to their health and growth. It involves the several processes of the assumption, elaboration, distribution, and final assimilation, of aliment. In plants, the first step is the absorption or inhalation of fluids, liquid or gaseous; the details of which will be found at the article ABSORPTION. The second step is the ascent of the sap through its proper and peculiar channel; to which article the

reader is requested to turn. The third step is the elaboration of the crude aliment, partly in the cells or vessels which form the skeleton or carpentry of the plant; but chiefly in the leaf when the sap has reached the summit. To the leaves and green parts the elaboration of the gases peculiarly belongs, as the several articles on the elaboration of the gases will evidently show. The fourth step is the descent of the cambium, or elaborated aliment, through its proper channel; which articles let the reader consult. The fifth and last step is the incorporation of the cambium, which is a sort of gum or mucilage, composed, as the chemists think, of an atom of water and an atom of carbon, convertible by slight changes into chromule, starch, sugar, lignin; and actually so converted in its descent, by means of further depurations which it receives from the tissue through which it passes, till it is assimilated to the vegetable substance by the vital action of the several organs, which have the property of imbibing and further elaborating this descending and alimentary fluid; as well as of incorporating into their tissue such molecules as are necessary to give them their due growth and expansion, and of expelling from it such molecules as may have become effete, or are no longer fit for vegetable function. Thus the cambium is expended in adding annually a new shoot to the summit, and a new layer to the alburnum, and liber of exogenous perennials; or in adding a new length, and a new crown of leaves, to the stem of endogenous perennials; as also in the forming of peculiar secretions, which it deposits in appropriate cells, vessels, or cavities; or totally expels from the system, till the process is checked by the colds of winter, and thus interrupted by a period of repose. For the further elucidation of this subject see also DEVELOPEMENT OF THE SEMINAL OVULUM, and EVOLUTION OF ELEMENTARY ORGANS, with the articles CAMBIUM and SECRETIONS.

OAK-APPLES.—Oak-apples are galls or monstrosities into which the buds of the oak-tree are often metamorphosed through means of the puncture made by insects in the depositing of their eggs. They are by no means of rare occurrence. Having observed upon an oak-tree some of the galls in question, about the end of May 1808, I had a few of them gathered for the purpose of examination. The largest was then about the size of a golden pippin, soft and spongy to the touch, and covered with a fine and glossy epidermis of a white colour, but changing in some places to red, and hence not much belying in appearance its vulgar name. At its base it was furnished with a number of scales or leaves, resembling a calyx, which proved upon examination to be the outer scales of the original bud. On cutting

the gall open, whether by a longitudinal or transverse section, a number of oval or cylindrical bodies were found embedded in its centre. They were the eggs or larva of the species of *Cynips* by which the bud had been punctured. But on some trees of the same species there was found a gall of a very different aspect, which, though nearly of the same size, was covered with a long and white shag, and did not exhibit the same fleshy texture when cut open. It was occasioned, however, by similar means; the eggs of the insect, of a different species, no doubt, being crowded together in the centre like a cluster of small seeds, united by the lower extremity, and covered by the wool. Having cut open some of both sorts, about the end of the month of June, the maggots of the former were now distinguishable by the aid of the microscope, complete in all their parts; and in the latter each egg was found to contain a fly. On the extremity of some of the branches a few fragments of galls, of the former sort, and of the preceding summer, were still to be seen, perforated with the holes through which the maggots or flies had escaped. The fragments were quite charred by means of the action of the atmosphere.

OCHREA.—The ochrea is a membranous sheath, being apparently a modification of the bracte, situated at the base of the petiole, and at the same time surrounding the stem, as in *Polygonum*.

ODOUR.—The odour of a plant signifies either the sensation which it impresses upon the organ of smelling, or the substance which is the cause of that impression. The former is well known to the fancier of fair and fragrant flowers, who cultivates the finest looking, or the sweetest scented, and values above all others the pink, the mignonette, and the lovely rose. The latter falls within the sphere of the investigations of the physiologist.

Linnæus institutes an arrangement of vegetable odours by which they are distributed into seven distinct classes, founded upon the peculiarity of the impression which they make on the sense of smell. 1st. The ambrosial, or musk-like, as in *Malva moschata*. 2nd. The fragrant, or simply sweet scented, as *Polyanthus*, *Jasminum*, *Viola*. 3rd. The aromatic, or richly fragrant, as in the pink, wall-flower, and leaves of the laurel. 4th. The alliaceous, or pungent, as in *Allium Cepa* and *Porrum*. 5th. The hircine, or fetid, as in *Orchis hircina* and *Hieracium foetidum*. 6th. The tetrus, or rankly fetid, as in *Stachys foetida*, *Cotula foetida*. 7th. The nauseous or disgusting, as in the flower of *Stapelia*, and Tobacco. [Phil. Bot. sect. 362.]

Chemists arrange the odours of vegetables according to their chemical properties, or to the mode of obtaining them. 1st. Extractive odours, obtained by distillation from plants without odour. 2nd.

Oily odours, insoluble in water, as the odour of the flowers of Jasmine and Jonquil. 3rd. Oily odours, but soluble in water, as those of rosemary and the Labiatae. 4th. Aromatic odours, changing vegetable blues to red, as the distilled water of Benzoin. 5th. Hydro-sulphurous odours, precipitating metals from their solution, as the distilled water of cabbage, and of cruciform plants. [Fourcroy.]

Perhaps the aroma of all plants is merely the more evaporable part of their volatile oil disengaging itself from its combinations. If it volatilizes quickly, it is soon exhausted, and the odour is gone; if slowly, its evaporation is protracted, and the odour rendered permanent, as in resinous woods, particularly the cedar.

Some plants or flowers exhale their odours particularly in the day, while the sun shines, as the *Cistus*, the Orange, the Labiatae; while others, particularly flowers of a dull and sombre colour, as *Hesperis tristis*, *Gladiolus tristis*, exhale them only in the night. But all vegetable odours are apt to become spasmodic if too highly concentrated, as the otto of Roses will readily show. Even sweet-scented flowers in too great abundance act injuriously upon the nerves, as the Jonquil, the tuberose, and even the humble violet. Hence, flowers, if placed in a bed-room, as is too much the custom, are fraught with the most dangerous consequences to the occupant. The flowers of *Malva moschata*, so placed, have been known to produce hysterics; and those of Nerium Oleander are said to have occasioned even death. The odour of the pollen is thought to have some relation to animal odours, being similar to that which is exhaled from the generative fluid of man. The pollen of the Chestnut and Barberry are said to exhibit this fact in a very unequivocal light. [Dec. Phys. Veg. 938.]

OFFSET.—The offset is a short lateral branch in some herbaceous plants, terminated by a cluster of leaves, and capable of taking root when separated from the parent plant, as in Sempervivum. It differs but little from the runner.

OILS.—Vegetable oils are of two kinds—the fixed and the volatile. The former are not suddenly affected by the application of heat; the latter are very inflammable.

I. Fixed oils are but seldom found except in the seeds of plants, and chiefly in such as are dicotyledonous. Yet they are found also, though rarely, in the pulp of fleshy fruits, as in that of the Olive, which yields the most abundant and valuable species of all fixed oils. Some seeds yield their oil merely by means of pressure, or pounding in a mortar; others require to be exposed to the action of heat, as to the vapour of boiling water, or the process of roasting, before they are subjected to the press. But the oil thus expressed is still full of impurities, to divest it of which the chemists employ a variety of processes.

Fixed oil, when pure, is a thick and viscous fluid of a mild or insipid taste, and without odour. Its colour is most frequently green or yellow. Its specific gravity is to water as 9.403 to 1.000. [Fourcroy.] It is decomposed by the acids, but with the alkalies it forms soap. At a temperature considerably below the freezing point it congeals and crystallizes. At the temperature of 600° of Fahrenheit it boils. By distillation it is converted into water, carbonic acid, carburetted hydrogen, and charcoal. Hence it is a compound of carbon, oxygen, and hydrogen.

Fixed oils are regarded as consisting of two sorts—fat oils and drying oils; the former inspissated by the action of the air into a sort of fat; the latter dried by the action of the air, and converted into a firm and transparent body. The principal species of fat oils are the following. 1st. Olive oil, expressed from the pulpy fruit of *Olea europea*. 2nd. Oil of Almonds, extracted from the fruit of *Amygdalus communis*. 3rd. Oil of Rapeseed, extracted from *Brassica Napus*, and *campestris*. 4th. Oil of Behen, extracted from the fruit of *Hyperanthera Moringa*. 5th. Castor oil, extracted by decoction from the seeds of *Ricinus communis*. The principal species of drying oils are Linseed oil, Nut oil, Poppy oil, and Hempseed oil. Some of them are occasionally used for dietetical purposes; but they are chiefly used by painters.

II. Volatile oils, which are known also by the name of essential oils, are of very common occurrence in the vegetable kingdom, and are found in almost all the different organs of the plant, to which they communicate a fragrant and aromatic odour. In the root of *Inula Helenium*, in the bark of *Laurus Cinamomum*, in the wood of *Laurus Sassafras*, in the leaves of the Labiatae, in the flowers of the Rose, in the fruit of pepper and ginger, and in the external integuments of many seeds, but never in the cotyledon, essential oils are uniformly to be found. They are extracted by expression or distillation; and perhaps every plant possessing a peculiar odour possesses also a peculiar and volatile oil, from which its aroma emanates. They are soluble in alcohol, but not readily converted into soaps. They are very inflammable, and are volatilized by a gentle heat. Like the fixed oils, they are lighter than water, on the surface of which they will float. They are much in request on account of their agreeable odour, and are prepared and sold by apothecaries or perfumers under the name of distilled waters, or essences; as well as employed also in the manufacture of varnishes and pigments.

OLEINE.—Fats and fixed oils were long regarded by chemists as homogeneous proximate principles of animals and of plants. But the researches of Chevreul and of Braconnet have shown that they are compounds. If the fat of pork is folded up in blotting-paper and

subjected to pressure, the paper absorbs a portion of it, which is a liquid oil. To this Chevreul gave the name of *oléine*, or *eläine*. The remainder is a dry, brittle, inodorous, semi-transparent mass, of a granular texture: to this he gave the name of *stearine*. It was afterwards shown by Braconnet that fixed oils, as oil of olive or oil of almonds, by being frozen and pressed in blotting-paper, may be separated into *stearine* and *oléine*, in the same manner as animal fats. Hence *oléine* is rightly claimed by the vegetable physiologist as a proximate principle of plants. A hundred parts of olive oil are said to yield 72 of *oléine*.

OLIBANUM.—Olibanum is a gum-resin obtained from *Juniperus Lycia*, a native of Arabia and the Levant. It is the frankincense of the ancients. It exudes from incisions made in the plant, and concretes into masses about the size of a chestnut. It is brittle, transparent, and of a yellow colour. It has little taste, but when burnt it diffuses an agreeable odour.

OMPHALODIUM.—The central point of the hilum, where the nourishing vessels enter the seed, is by Turpin called the omphalodium.

OPERCULUM.—The lid which covers the orifice of the urn of the Mosses is the operculum.

OPIUM.—Opium is the juice of *Papaver somniferum*, the White Poppy, inspissated by exposure to the atmosphere, and reduced to a solid mass. Its colour is a yellowish red, its odour strong, its consistence somewhat gum-like, and it tinges the saliva green. It consists of three ingredients, that seem to determine its properties—morphia, narcotine, and meconic acid; which last is usually combined with morphia, and has not hitherto been found except in opium. It crystallizes in fine needles, soluble in water and in alcohol.

OPOBALSAMUM.—This resin, which has been much famed for its medical virtues, is the produce of *Balsamodendron Gileadense*, and is the Balm of Gilead so much celebrated in Scripture. Pliny says it was first brought to Rome by the generals of Vespasian. [Lib. xii. 25.] It is obtained in a liquid state from incisions made in the bark, of a light yellow colour, but somewhat bitter to the taste. It is less in repute as a medicine than it was in ancient times; but it is still in high estimation among the Turks as a cosmetic, and is so very highly valued that its exportation is prohibited.

OPOPONAX.—The plant from which this gum-resin is obtained is the *Pastinaca Opoponax*, a native of the countries of the Levant. It exudes in the state of a milky juice from incisions made in the root. It is afterwards dried in the sun, and is generally to be met with in lumps of a reddish colour, but white within. Its taste is bitter and acrid, and it forms with water a milky solution.

ORCANETTE.—Orcanette is a peculiar colouring matter extracted from the root of *Anchusa tinctoria*, known to the dyers by the name of orcanette. It is insoluble in water; but soluble in ether, alcohol, the acids, and the oils, to which it gives a colour of a beautiful red. It is soluble also in the alkalies, which change it to blue; but the acids restore its red. [Raspail.]

ORCINE.—Of late years, this name has been given by chemists to the colouring principle of *Lichen Roccella*. If the plant is dried and reduced to a powder, and then macerated in water, a red precipitate is obtained, by muriate of tin, that forms a beautiful, but perishable dye. But if it is applied to marble, it stains it of a beautiful violet, that is permanent for years. [Thomson.]

ORGANOGRAPHY.—This term is made use of by some writers to denote that department of botany which treats specifically of the organs of plants. See NOMENCLATURE.

ORIGIN OF BUDS.—Phytologists have at different times entertained very different opinions concerning the origin of buds. Some have regarded them as originating in the bark, others in the alburnum or wood, and others in the pith. For a brief view of these several hypotheses, with the grounds on which they rest, see the article BUD.

ORTHOTROPOUS.—This Greek compound, of *ορθος* straight, and *τρεπω* to turn, is employed to denote a peculiar position of the vegetable ovulum, as also of the vegetable embryo, occurring in certain species. See DEVELOPEMENT OF THE VEGETABLE OVULUM.

OSMAZOME.—This substance is common to both the animal and vegetable kingdoms. It is obtained by evaporating meat broths, the serum of blood, or even a decoction of mushrooms. The residue is osmazome; transparent, of a reddish brown colour, of an aromatic odour, but of an acrid savour. It is soluble in alcohol, and in water, from which last it is precipitated by nitrate of lead. [Raspail.]

OVARY.—The ovary is the lower extremity of the pistil, enclosing the ovula in its cavity, or cavities, and supporting the style and stigma. In its attachment it is sessile, as in *Arbutus*, or stipitate, as in the Poppy. If it originates below the calyx, it is said to be inferior, as in the apple; if above, or rather within the calyx, it is said to be superior, as in *Primula*. Yet some botanists contend that it is always superior; and when it seems otherwise, it is only because the lower portion of the calyx is so intimately incorporated with the ovary as to seem to be part of it [Ventenat], as in the case of the apple and pear. Its figure is globular, or egg-shaped, or oblong, or compressed, as in the Vetch. In its structure it is simple, that is, containing only a single cell, as in the pea and bean; or compound, that is, containing two or more cells, as in *Euphorbia*. That portion of the ovarium in

which the ovula originate is called the *placenta*. It is either a part or the whole of one angle of each cell, to which the ovula are attached, either immediately, or through the intervention of a small cord, called the umbilical cord.

OVULA.—The ovula are small, semi-pellucid, and pulpy bodies, issuing from the placenta, and changing gradually into seeds. They are so minute, and so delicate, and so easily crushed under the dissecting knife, that they had long baffled all the attempts of the vegetable anatomist, whether to detect their structure at any given stage of their developement, or to trace the several and successive changes which they undergo, in their progress towards maturity. But by the late investigations of Brown, Brongniart, Turpin, Treviranus, and Mirbel, the difficulty has been at last surmounted, and this obscure and intricate department of the vegetable anatomy placed in a conspicuous light. For further details on this subject, see DEVELOPEMENT OF THE VEGETABLE OVULUM.

OXALATE OF LIME.—This salt is said to be found in many plants under the form of small needles or crystals, which have been denominated raphides. They abound in the milky juice of Euphorbia, and in the fluid that issues from the scape of a Hyacinth when wounded.

OXYGEN.—Oxygen gas is a permanently elastic fluid, capable of indefinite expansion and compression. It is readily obtained from the black oxide of manganese, by reducing it to a coarse powder, and heating it in a gun-barrel, or earthen retort. As soon as the retort becomes ignited, the gas is disengaged. It may be obtained also from the green leaves of vegetables. Fill a bell-glass with water, together with some fresh-gathered green leaves. Invert it in a shallow vessel filled with the same fluid. Expose it thus located to the direct rays of the sun, and oxygen gas will be liberated, depressing the water, and occupying the upper part of the receiver.

This gas has neither taste nor odour. Its specific gravity is to atmospheric air as 1.096 to 1.000. It is not absorbed by water; but it is absorbable by all bodies in a state of combustion. Hence all bodies in a state of combustion receive an addition to their weight, in proportion to the quantity of oxygen absorbed. It constitutes about a fifth part of the mass of the atmosphere, so that we unavoidably inhale it at every inspiration. But it is respirable even in its pure state, and is eminently conducive to the support of animal life. A mouse, a bird, or other small animal, will live six times longer in a vessel containing oxygen than in one of the same dimensions containing atmospheric air. But it is equally conducive to the support of vegetable life, and equally necessary to the exercise of vegetable function. Without an abundant supply of oxygen, vegetables will

not thrive, and if wholly deprived of it they will inevitably die. For the detail of its agency in the process of vegetation, let the reader consult the articles on the GERMINATION OF THE SEED, and ELABORATION OF OXYGEN.

PANICLE.—The panicle is an assemblage of flowers supported upon a primary and terminal peduncle or axis, that is irregularly divided into secondary peduncles, which are sometimes again subdivided into tertiary peduncles or pedicles. It is exemplified in *Bromus arvensis*, and *Avena flavescens*, and may be regarded as resembling a sort of loose spike.

PAPILIONACEOUS FLOWER.—Sometimes the petals of a tetrapetalous corolla are irregular, and disposed so as to exhibit a slight resemblance to a butterfly, in which case the flower is said to be papilionaceous, and is exemplified in that of the pea and bean, the petals of which, and of all similar flowers, are so peculiar in their form or position as to have received distinct appellations. The upper petal, which is generally large and furnished with an erect border, is denominated the *standard*. The lower petal, which is situated opposite to the standard, and hollowed out in the form of a boat, is denominated the *keel*; and the two remaining petals, which are situated in an opposite position, one on each side of the keel, are denominated the *wings*. If the keel or boat is composed of two distinct pieces, as is sometimes the case, then the papilionaceous flower is quinquepetalous.

PAPILLÆ.—The papillæ are minute, transparent, and elevated points, emerging from the cuticle of the leaf or flower, and filled with a peculiar fluid. They are the utricular glands of Guettard, and are well exemplified as they occur on the leaves of the Ice Plant.

PAPPUS.—This term is sometimes employed to denote the down which many botanists regard as the proper calyx of Compound Flowers. See DOWN.

PARASITES.—There are certain plants, many of them Phænogamous, but more, perhaps, Cryptogamous, that will vegetate neither in the earth nor water, but on certain other plants, to which they attach themselves by means of roots that penetrate the bark; or into the interior of which they insinuate themselves in a more mysterious way, and from the juices of which they do often, but not always, derive support. On the ground of these distinctions, we institute the following division of the subject. I. Phænogamous, or Vascular Parasites, including—1st. Such as attach themselves to the stem; 2nd. Such as attach themselves to the root. II. Cryptogamous or Cellular Parasites, comprehending—1st. Superficial Parasites; 2nd. Intestinal Parasites.

I. Phænogamous or Vascular Parasites, whether attaching themselves to the stem or root.

1st. Parasites attaching themselves to the stem. Plants of this description are divided into *True* and *False*. *True* parasites derive their nourishment chiefly from the supporting plant, which they imbibe through the medium of their roots; but they are furnished at the same time with vessels, and even with spirals conducting sap or other peculiar fluids, as well as with green leaves, capable of discharging the functions of leaves, that is, of inhaling and elaborating carbonic acid and oxygen gas. *False* parasites do not receive their nourishment from the plant on which they grow, but merely their support; whence we conclude that they are not furnished with roots capable of imbibition.

The true and stem-selecting parasites belong chiefly to the family of the Loranthaceæ, and of them the best known is the Mistletoe or *Viscum album*. It is found most frequently on the Hawthorn, or on the Apple-tree; but sometimes also on the Oak. The fruit of it when ripe is a soft, white, and shining berry, filled with a glutinous and sweetish juice; and about as large as a pea. If this berry, whether by accident or by design, is made to adhere to the trunk or branch of either of the foregoing trees, which from its glutinous nature it may be readily made to do, it germinates by sending out a small globular body attached to a pedicle, which, after it acquires a certain length, bends towards the bark, whether above it or below it, into which it insinuates itself by means of a number of small fibres which it now protrudes, and by which it abstracts from the plant the nourishment necessary to its future developement. When the root has thus fixed itself in the bark of the supporting tree, the stem of the parasite begins to ascend, at first smooth and tapering, and of a pale green colour, but finally protruding a multiplicity of branches, by continuing to divide into jointed forks. The leaves are of the colour of the stem, tongue-shaped, entire, smooth. The plant is an evergreen, not readily distinguished in the summer, when the leaves of the tree on which it grows are fully expanded; but becoming very conspicuous in the winter, from the green and bushy appearance of its leaves, or from the white and shining appearance of its ripened berries.

It seems to have been thought by some botanists that the roots of the Mistletoe penetrate even into the wood, as well as through the bark. But the observations of Duhamel show that this opinion is not well founded. The roots are, indeed, often found within the wood, which they thus seem to have penetrated by their own vegetative power. But the fact is, that they are covered merely by the additional layers of wood that have been formed since the fibres first insinuated

themselves into the bark [Phys. des Arb. liv. v.], and are united to the first layer merely by agglutination. By what means are the fibres of the root enabled to penetrate the bark of the supporter? M. Decandolle thinks that they enter the bark by means of producing a sort of gangrenous but circumscribed affection in that portion of it which lies immediately beneath them, so that thus its resistance is overcome, and the passage of the root rendered easy.

Among the ancient Druids and aboriginal inhabitants of this country the Mistletoe of the Oak was revered as sacred, and its medical virtues were held in the highest estimation. To strip the Oak of its parasite, or to cut down the tree on which it grew, was regarded by the Druids as sacrilege—a superstition that kept its hold of men's minds long after Druidism fell to rise no more. Evelyn says “he was told of the disasters which happened to two men who, not long since, felled a goodly oak near Croydon, upon which a branch of Mistletoe grew, which they sold—the one losing, soon after, his eye, the other breaking his leg, as if the Hamadryads had revenged the indignity.” [Sylva, chap. xxxv. sec. 15.] Yet it forms no prominent article in the *Materia Medica* of present times; except that it is still regarded by farmers and cow-doctors as being of peculiar efficacy in certain diseases incident to cattle; and by the lower orders of the people in general, as possessing some peculiar medical properties; by which they seem to think that it operates as a sort of a charm, particularly in its capacity of affording a preventive to sterility; which accounts for the institution of the ancient and still prevailing custom with the inhabitants of the cottage, of gathering boughs of it, and suspending them from the ceiling of their apartments about the season of Christmas, when the fruit is ripe.

The false parasites, or stem-selecting epiphytes, belong chiefly to the tribe of the Epidendra or Air-plants. These we may exemplify in *Epidendron Flos aeris*, a native of India beyond the Ganges. It was formerly regarded as a truly parasitical plant, because it is generally found growing on other plants. But it is possessed of a well-known property which shows that it cannot be truly parasitical after all. It will continue, says M. Loureiro, to vegetate for years, even when taken from its natural station and suspended from the ceiling of a room, producing blossoms of the fairest colours and the richest smell; from which we may fairly infer that it derives its nourishment wholly from the atmosphere, and not from the plant to which it adheres.

Cuscuta europea, or Dodder, a plant of a very different family, though it is to be regarded as a truly parasitical plant in the issue, is by no means such in its origin. The seed of this plant, when it has fallen

to the ground, takes root originally by sending down its radicle into the soil, and elevating its stem into the air. It is not yet, therefore, a parasitical plant. But the stem which is now elevated above the surface lays hold of almost the first plant that it meets with, though it is particularly partial to hops and nettles, which it ascends by twining round the stem, attaching itself by means of little parasitical roots, at certain points of contact, and finally disengaging itself from the soil altogether, and becoming a truly parasitical plant. Thus, though it was not parasitical in its origin, it is parasitical in its issue.

2nd. Parasites attaching themselves to the root.—Parasites of this division are, for the most part, of a dull or dirty colour, even though exposed to the influence of the light of the sun. Their leaves are scarcely foliaceous, but rather in the form of scales. They have neither stomata nor spirals: hence they can neither form the green chromule, nor exhale moisture, nor elaborate sap, nor carbonic acid gas, like other plants; and hence also they require to be furnished with a sap already duly elaborated, which they draw up from the supporter by their roots. Neither have their seeds cotyledons, or, if they have, they are so minute that they cannot germinate unless furnished by another plant with the nourishment which other seeds derive from their cotyledons. They are therefore true parasites even in their origin. [Dec. Phys. Veg. 1405.]

The most remarkable parasites of this division are to be met with among the *Rafflesiaceæ* and *Orobancheæ*. The former family gives us *Rafflesia Arnoldi*, the most gigantic flower in the world, measuring three feet in diameter, and yet it is merely a parasite. It has no stem of its own, but fixes itself by a small root in some crack or hollow of the root or stem of a ligneous species of *Cissus*. It shows itself first in the form of a small knob, which, when cut through, exhibits the infant flower. In three months the petals have expanded, and are in their full maturity. They soon begin to wither and to fade, extricating in their decay the seeds or spores that are dispersed throughout their pulpy mass. This extraordinary and unparalleled production is called by the natives Krûbût, or the Great Flower; or, Ambum Ambum—wonder-wonder, or the Flower of Flowers.

The different species of *Orobanche*, or Broom-rape, do not attach themselves indifferently to the root of any plant, but each is partial to some peculiar tribe of plants. Thus *Orobanche major* is found chiefly on the roots of the leguminosæ; and *Orobanche ramosa* on the roots of hemp. It has been thought that they are not altogether true parasites, because they sometimes send out lateral radicles into the earth. But I do not find that they let go their original hold. If not, then they are still true parasites.

Lathræa Squamaria is also one of the most remarkable of root-selecting parasites. If the reader is desirous of obtaining a clear and intelligible view of its mode of attachment and growth, or of the structure and functions of its several organs, together with the rationale of the peculiar phenomena which it presents to the contemplation of the physiologist, let him peruse and re-peruse the very valuable paper of Mr. Bowman "On the Parasitical Connexion of *Lathræa Squamaria*." [Lin. Trans. Vol. XVI. Pt. ii.] This parasite does not, like *Orobanche*, attach itself to the root of the supporter merely by a single foot or point; but by sending out a number of small fibres, each furnished with a minute tubercle, by which it clings to the surface of the supporting root, the bark of which it penetrates, as Mr. Bowman thinks, "by means of some chemical change or corrosion, effected by the union of their respective juices." Further, the *squamæ*, or scales of the subterranean stem, Mr. Bowman regards as being real leaves; and the reasoning by which the opinion is supported, if not altogether conclusive, is at least very plausible, as well as very fairly claiming the notice of the physiological enquirer.

II. Cryptogamous, or Cellular Parasites, belonging chiefly to the tribe of the Fungi, but partly to that of the Algæ.

1st. Cryptogamous parasites attaching themselves to the superficies, and thought to be somewhat analogous to parasitical animals that attack the skin. We will content ourselves with exhibiting such examples as are furnished by species belonging to, or allied to, the genera *Erysiphe* and *Rhizoctonia*.

The Erysiphidæ attach themselves to the surface of the leaves. They are small, globular tubercles, at first yellow, then black, protruding fine white filaments, that radiate, and cross, and form a sort of net-work, which extends ultimately over almost the whole expansion of the supporting leaf. The leaves of the hazel, ash, willow, birch, and poplar, are said to be peculiarly liable to attack, and the plant attacked is often so much injured by its parasitical retainer, that it can produce neither flower nor fruit.

The Rhizoctonidæ are also superficial parasites, but they settle on the root in the shape of small fleshy tubercles, protruding slender threads that ramify like those of a *Byssus*, and bear at different distances secondary tubercles, which attach themselves to the surface of the root, which they almost wholly cover, draining it of its nourishment, and often killing the plant. The ravages of that species which attaches itself to the roots of cultivated Saffron are well known. It spreads so rapidly, so irresistibly, so fatally, that it has obtained from the English the name of Death-Mould; and from the French that of *La mort du Safran*.

2nd. Cryptogamous parasites, nestling in the interior of the plant, and thought to be analogous to parasitical animals that attack the intestines. How these plants find their way into the interior is a mystery which botanists have not yet been able to unriddle in a satisfactory manner. Some have supposed the re-productive spores by which they are propagated to be so light and so fine as to float on the atmosphere, and thus to enter the plant through the stomata of the leaves. This solution M. Decandolle rejects; because stomata, as he thinks, are organs of exhalation merely; because the parasites in question are found on plants that have no stomata; because you cannot communicate the disease by inoculation; and because the escape of the spores by the stomata is no proof that they have entered by them. A more plausible conjecture is that by which the spores are supposed to have sunk into the soil, and to enter the plant in mixture with the water which the spongiolæ absorb, whence they are carried by the ascending sap to the leaves, or to such other organs as are favourable to their developement. This hypothesis receives support from the fact of the more abundant developement of the spores in warm and moist weather, when the absorption of the roots is the most active, as was observed by M. Decandolle; and from that of the sowing of the spores of the *Uredines* along with sound wheat, as was done by M. Fee. The wheat thus treated became subsequently diseased; the spores being doubtless absorbed by the spongiolæ, and conveyed by the sap vessels to the stem and leaves of the plants, or to other favourite localities. In such they “increase and multiply” rapidly, lurking immediately beneath the epidermis, which they finally burst under the form of a fine, but often rusty-looking, powder, which is to be regarded as an assemblage of new spores, or sporidia, fit for future propagation. They attack, especially, our finest grains, as wheat, maize, barley, which they often damage to a great extent; or the leaves of our finest fruit-trees, as those of the pear. They are known to the gardener or husbandman under the names of blights, mildews, rust, and by a variety of other appellations almost too tedious to mention; and their principal ravages are thought to be committed by the several species of *Æcidium*, *Puccinia*, *Uredo*, *Sclerotium*, some of which will be more particularly noticed under the head of the diseases which they occasion.

PARENCHYMA.—The parenchyma of some writers seems to imply merely what is otherwise denominated cellular tissue. We prefer that acceptation of it by which it is made to be equivalent to the term pulp—that is, a cellular tissue whose cells are filled with a *chromule*, whether green, as in the interior of the leaf, or colourless, as in the interior of a ripe apple.

PARIES.—The wall, or external boundary, of any containing organ, is its paries; as the wall or paries of the ovary containing the incipient ovula, or the ripened seeds.

PARTITIONS.—Partitions are the septa or dissepiments by which an ovary is often divided into several cells bearing placentæ, as in the genus *Iris*. All dissepiments are vertical. They cannot be horizontal, because they cannot have a direction different from that of the carpella. They are equal in number to the carpella out of which the pistil is formed. A single carpellum can have no dissepiment.

PEDICLES.—The ramifications of the main peduncle, when it has any, take the name of pedicles.

PEDUNCLE.—The peduncle is a flower-stalk issuing from the stem or branch, and supporting a flower or flowers, but not leaves.

PELLICLE.—Any thin, filmy membrane is a pellicle; but Gærtner applied the term to the fine epidermis that covers the surface of some seeds, as those of *Salvia verbenaca*.

PERFECT PLANTS.—Plants furnished with the full complement of parts and organs common to vegetables in general are said to be Perfect. They are said also to be Phænogamous, as being furnished with conspicuous flowers; because conspicuous flowers are the glory of the plant, and in many plants they are wanting. Hence, if any plant is deficient in one or more of the parts or organs common to vegetables in general, such plant is said to be imperfect. It is said also to be Cryptogamous—that is, destitute of conspicuous flowers; because in plants called imperfect, conspicuous flowers are wanting. See IMPERFECT PLANTS.

PERIANTH.—The term perianth was originally employed to designate the outer envelope or calyx of any flower, particularly if it was so formed as to resemble a cup. But it seems now to be confined in its application to the case of flowers having but a single envelope, of which it would be difficult to say whether it is calyx or corolla.

PERICARP.—The pericarp is the exterior portion of the ripened ovary, of which the interior portion is the seed. It is regarded as consisting of three distinct parts,—the epicarp, or external integument of the fruit; the endocarp, or putamen immediately investing the seed; and the sarcocarp, or fleshy pulp that lies between both. You have them well exemplified in the peach, in which the outer skin is the epicarp, the fleshy pulp the sarcocarp, and the stone or putamen the endocarp. The base of the pericarp is the point where it unites with the peduncle; the apex, the point where the style was.

When the fruit has arrived at maturity, some pericarps open of their own accord, and discharge the seeds: such are said to be dehiscent. The pieces into which they separate are called valves; and the axis

from which they separate, where a distinct axis exists, is called the *columella*. The dehiscence is septicidal,—that is, through the dissepiments, as in *Rhododendron*; or loculicidal,—that is, through the valves, as in *Lilac*; or sutural,—that is, along the inner edge of a single fruit or carpellum, as in the pea; or septifragal,—that is, by a separation of the dissepiments from the valves, as in *Convolvulus*; or, lastly, it is transverse to the suture of the valves, as in *Anagallis*. Some fruits, though ripe, remain perfectly closed, and do not open but in decay, or in germination. Such are said to be indehiscent.

Botanists enumerate a great variety of modifications in the form or fabric of pericarps; but they are apt to institute distinctions without a warrantable difference, and thus they introduce a chaos rather than a regular superstructure. The following species of pericarp are the most common:—The Capsule, the Pomum, the Berry, the Nut-shell, the Drupe, the Silique, the [Legume, the Cone,—specific descriptions of which will be found in their alphabetical order.

PERICHÆTIUM.—The perichæcium is the fence or calyx of the mosses, being an assemblage of loosely imbricated scales surrounding the fertile flowers, and terminating in a fine hair or bristle, as in *Hypnum*.

PERIGYNOUS INSERTION.—Though it seems to be admitted that the stamens do always originate in the base of the ovarium, yet botanists are in the habit of saying that they are inserted into the calyx or corolla, because it often happens that they adhere to these organs up to a certain point, as in *Primula* and in *Rosa*, and hence such insertion is said to be perigynous.

PERIPHERICAL.—The embryo is said to be peripheral when it is accumbent on the external integuments, as in the grasses. See **DISECTION OF SEEDS**.

PERISPERM.—The testa of Gærtner is by some botanists denominated the perisperm. But it does not seem to be a term that is at all wanted.

PERISTOMIUM.—The fringe that surrounds the mouth of the capsule of the mosses is the peristomium. It consists of a circular and double row of fine and tooth-shaped substances, sometimes united into one set, and sometimes divided into several sets.

PETALS.—The divisions of the corolla or inner envelope of the flower are denominated petals. They always alternate with the sepals or divisions of the calyx, like which they are either distinct or united together by their margins; only they are not green, or but very rarely so, though they are of colours that are much more gaudy,—white, blue, red, or yellow.

PETIOLE.—The foot-stalk that supports a leaf is very generally called its petiole.

PHOSPHATES.—Phosphate of lime is said to have been found in the roots of Peony and the White Water-Lily; and M. Raspail has detected it in the leaves of *Phytolacca decandra*, and in the bulbs of the Orchis, Ornithogalum, and Narcissus, under the form of needle-shaped crystals attached to the exterior of the cells. Phosphate of magnesia is said also to have been detected by Fourcroy in the pollen of the Date-tree.

PHYTOGRAPHY.—This term is made use of by some writers to denote that department of Botany which describes the entire plant.

PHYTOLOGY.—If we regard the term physiology as denoting that branch of science which treats of, and accounts for, the phenomena of life, then it will be evident that it divides itself naturally into two grand departments; namely, *zoology*, involving the phenomena of animal life; and *phytology*, involving the phenomena of vegetable life. It is to the elucidation of the latter of these departments that the present work is chiefly devoted. The former we can but briefly notice in our concluding article. But although it has been our object throughout, to make each article in some degree historical, wherever the case admitted of it, yet we think it will still throw additional light on the subject, if we present to our reader, in a single view, a brief sketch of the history of phytology from the earliest times.

The first, faint, traces of phytological speculation with which the study of antiquity furnishes us, are those that lie scattered in the writings of the earlier Greeks: They are of no value, however, as tending to the advancement of science; but they are important as exhibiting “the form and pressure” of phytology in its first and rude beginnings. Empedocles seems to have been the first who ascribed sexes to plants; and having endowed them, not only with life and sensation, but also with desires and passions, may, therefore, be regarded as the original author of their “*Loves*.” Democritus investigated the cause of vegetable tastes and odours, which he attributed to *the form* of their primitive particles; the sweet being large and round, the bitter small and angular. Yet there is nothing worth notice to be met with on the subject of vegetable physiology, till we come down to the time of Theophrastus, the successor of Aristotle, and prince of ancient botanists, who being duly initiated in the principles, and imbued with the sound learning of his great master, applied himself to the investigation of the vegetable kingdom with a zeal and industry worthy of the pursuit, and produced as the result of his labours two very remarkable works—the one entitled Περὶ Φυτῶν Ἰστορίας; the other, Περὶ Φυτῶν Αἰτιῶν. In the former he attempts

to describe and arrange the plants then known ; and in the latter to account for the phenomena of vegetation. His botany, as well as his physiology, is of course extremely imperfect ; though his works with all their defects are still of great value, as presenting us with an interesting memorial both of the knowledge and the philosophy of his age.

Thus, while he points out with sufficient precision the various modes of vegetable propagation, as by seeds, buds, or runners, he lays it down as quite certain, that plants are occasionally propagated by what has been called equivocal generation ; springing up spontaneously out of the earth, from the mixture of moist and dry particles, or from putrid and decaying substances lodged in the soil. The doctrine of the sexes of plants is also recognised, though not upon the principles now established. The tallest and loftiest he holds to be males ; and those of the most rapid growth to be females ; though the former are said to bear fruit, sometimes, as well as the latter. The efficacy of caprification is accounted for thus : The gnats that perforate the fig consume the superabundant moisture, and let in, at the same time, a free supply of air, so that the fig can now, as it were, breathe ; and so it ripens ! Parasitical plants are thought to spring from corrupted matter generated in the subjects on which they grow ; and the transmutation of one species into another, as of wheat into darnel, which is implicitly believed, is thought to be owing to a sort of corruption of superabundant juices in the plant degenerating. Though this is not very good philosophy, yet there are many acute remarks and the record of many judicious experiments in Theophrastus. We have, for example, a very intelligent account of the effect of the topping of beans in cultivation ; of the stripping of a ring of bark from a tree, and even of the extracting of a portion of the *pith*, with a view to ascertain the consequences on the health and fertility of the plant. We have also a great variety of judicious remarks on soils, manures, seasons, cultivation, grafting, and diseases, the greater part of which will stand a comparison even with the best agricultural maxims of the present times, except in as far as husbandry has been elucidated by chemistry.

Still it is evident that the study of plants began to decline among the Greeks along with the decline of empire, and to emigrate with the other arts and sciences into Italy ;

“ Græcia capta ferum victorem cepit, et artes
Intulit agresti Latio ;”

HOR. EPIST. I. Lib. ii.

where it appears to have been, at least, well received, if not very cordially cherished. From this time the Romans began to improve their agriculture, and to show some taste for gardening and ornamental plantations. But we have no reason to think that they proceeded on

scientific principles; for even in the works of Dioscorides and Pliny, those great luminaries of the botanical world during the first centuries of the Christian era, we find nothing that advances the progress of phytology one step beyond the stage at which it stood in the time of Theophrastus. Further, the learning of the dark ages was not phytological, nor of the first ages succeeding the revival of learning; though the study of plants was not neglected. For even Bacon seems to have had but very vague ideas on the subject, and to have done but little to improve this branch of science. If we look into his *Sylva Sylvarum* we shall find that he too supports the doctrine of equivocal generation, and quotes as worthy of belief the transmutation of barley into darnel, or wild oats. The Mistletoe, he thinks, is not produced from seed, but from superabundance of nourishment in the parent tree; and mosses that grow on trees are said to be nothing more than a sort of excretion of juice which the plant cannot assimilate.

Yet, though Bacon gives but a lame account of the phenomena of vegetation, he has preserved, like Theophrastus, a record of some curious experiments, which show that the spirit of enquiry was again revived; and if he did not actually add to the amount of phytological knowledge, he, at least, pointed out the way of successfully doing so to others. Accordingly, we find that a variety of phytological experiments, founded on the principles, and modelled on the method, he had so powerfully recommended, were instituted soon after the publication of his works, and followed by the happiest results. The two most distinguished of the phytologists of that period were Grew and Malpighi; the latter an Italian, the former an English physician. They had no mutual intercourse, and yet their experiments and observations are so nearly alike that the one might seem copied from the other. The characteristics of both are minute and accurate observation, careful experiment, and cautious deduction from a large collection of instances. Hence we find that no organ of the plant escapes their inspection—roots, trunks, branches, leaves, flowers, fruits with their appendages, are all subjected to the most rigid and minute scrutiny; as well as those parts and organs which are discoverable only by the dissection or anatomy of the plant—the pith, the wood, the bark, the epidermis; together with the fibres, tubes, or membranes into which they are further separable. This enquiry is followed by a careful enquiry into the respective uses of each, in the economy of vegetation; which is ascertained by watching with the most unwearied assiduity the phenomena of vegetable life,—the functions of the several organs of the plant,—the “*latens processus naturæ, in casu ubi fit inquisitio ex quibus initiis, et quo modo et quo processu herbæ generuntur, a primis concretionibus succorum in terra, a seminibus, usque ad*

plantam formatam, cum universa illa successione motus, et diversis et continuatis naturæ nixibus." [Nov. Org. lib. ii. Aph. v.]

It was by such patient and cautious investigations that our phyto-logists thought themselves at last warranted to conclude, that the presumed pores of the epidermis covering the root are the organs destined for the absorption of the moisture of the soil; the *spongiolæ* not being as yet detected; that the longitudinal tubes of the *alburnum* are the vessels through which the sap ascends; that the spiral tubes are *tracheæ* or air vessels; that the leaves are lungs or organs of elaboration; and that the elaborated juice or cambium, descending between the wood and bark, is the substance out of which the new layer of wood and of bark is formed. They were not quite so successful in the assigning of causes. Malpighi, to be sure, ascribed the ascent of the sap to a contraction of the vessels conveying it, which he presumed, but on very equivocal grounds, to be furnished with valves, to counteract the effects of gravitation; and Grew ascribed it to the volatile nature of the sap itself, aided by capillary attraction. The latter was unluckily misled, by the prevailing philosophy of the times, to ascribe too much to the agencies of nitrous particles, and of fermentation—an agency, in reality, far more obscure than the thing to be explained. Malpighi, on the other hand, had a passion for tracing out analogies between the functions of the several animal organs, and those of the vegetable subject, and it must be confessed that he has often succeeded. In investigating the process of the generation and growth of the seed, he has carried this principle to its greatest length, and has found similar parts and similar membranes in both, developed in a similar order—the ovary, chorion, umbilicus, sacculus coliquamenti, amnios, embryo. In describing the parts of the flower, he speculates also upon their uses, and represents the stamens and anthers as being merely excretory organs, and the pollen as the substance excreted. He may be said, therefore, to have failed in assigning a function to the stamens. But Grew was more lucky; for either he had conceived of himself a correct notion of the true use of the pollen, or he acquiesced in it as soon as it was suggested. His own short account of it is as follows: "Our learned Savilian Professor, Sir T. Millington, told me that he conceived *the attire* (stamens) *doth serve as the male*, for the generation of the seed. I immediately replied that I was of the same opinion, gave him some reasons for it, and answered some objections which might oppose them." [Grew's Anat. b. iv. c. 6.] This we believe to have been the first glimpse that was ever caught of the true and proper use of the stamens, and it may be dated about the year 1676. The conjecture was not lost sight of by contemporary or succeeding botanists. Ray, Camerarius,

Geoffry, Vaillant, all adopted the opinion, and added something in corroboration of it. But still the fact was not established upon the sure foundation of induction, till at last there appeared a genius duly qualified to accomplish the arduous task; namely, the celebrated Linnæus, the undoubted prince of botanists; who by collecting into one body all the evidence of former observations, and by adding much that was original of his own, nothing concealing, nor setting down aught in exaggeration, solved at last the important problem, and proved, beyond all controversy, the fecundating agency of the pollen, and the universality of the sexes of plants. Such was the fruit of his industry, and the triumphant result of his steadfast adherence to the golden rule of the great founder of the experimental mode of enquiry: “Siquid subsit in aliqua narratione dubii, vel scrupuli, id supprimi, aut reticere, omnino nolumus; sed planè et perspicuè adscribi, notæ aut moniti loco;—cupimus enim, historiam primam, veluti facto sacramento de veritate ejus in singulis, religiosissimè conscribi, cum sit volumen operum Dei, et tanquam Scriptura altera. [Parasc. ad Hist. Nat. et Exp. Aph. ix.]

We cannot now stop to enquire into the merits or defects of the sexual system of Linnæus; or to compare it with the rival and more natural system of Jussieu. We notice it merely *en passant*, and hasten to introduce the distinguished names of Hales, Bonnet, Duhamel, Hedwig, Spallanzani, Mirbel, Knight, Dutrochet—each of whom, following in the path opened up by Grew and Malpighi, has individually signalized himself in the field of phytological investigation, and contributed something to the advancement of the science. Thus, from the *ensemble* of their joint labours we have the anatomy of every organ demonstrated, as also an account of almost all the important phenomena of vegetation, together with a variety of speculations respecting their causes, whether satisfactory or otherwise,—as the irresistible descent of the radicle, and ascent of the plumelet; the peculiarities of the growth of roots and stems; the origin of buds and branches; the ascent of the sap, and descent of the proper juice or cambium; the irritability and movements of the vegetable subject; as also the action of heat and light, together with the fall of the leaf, and the natural decay and death of the plant. To the above distinguished names we ought also to add the names of Amici, Brongniart, Brown, as having more recently achieved, by their microscopical dexterity, the illustration of the most recondite and untractable of all phytological subjects; namely, that of the obscure and mysterious process of vegetable fecundation.

It will be observed that the above enquiries regard only the *physical* phenomena of vegetation. The *chemical* phenomena were not yet

duly attended to by the earlier phytologists, though plants had been often subjected to the investigations of the chemist. But the first experimenters seem to have had in view nothing beyond the mere analysis of their constituent parts, or rather of their medical properties; which they endeavoured to ascertain by means of the processes of infusion, decoction, evaporation, distillation, and combustion, torturing the vegetable subject in every possible way, and making much use of the crucible. It cannot be said that their researches were altogether unprofitable; but certainly they did nothing to elucidate the phenomena of vegetation. The key to that mystery may be said to have been first found by Priestley, when about the year 1771 he discovered the extrication of oxygen gas, by the leaves of plants, when exposed under water to the rays of the sun. The path thus opened up was afterwards successfully explored by Ingenhouz and Senebier, who extended their researches to a variety of other phenomena; and from that time chemical phytology has continued to attract the notice of almost all chemists of distinction; among whom we may particularly mention Lavoisier, Fourcroy, Vauquelin, Gay Lussac, and Thenard, in France; and in this country, Chenevix, Thomson, Ellis, and Davy. But the individual who, after Priestley, has perhaps the strongest claim to originality in these investigations, is Saussure the younger; who, in the true spirit of the Baconian philosophy, has watched and investigated, not merely the phenomena of vegetable life, but even the phenomena of vegetable death and decomposition; demonstrating the peculiar and indispensable agency of oxygen in the germination of the seed; the absorption of moisture by the root; its elaboration in the leaf, by the alternate inhalation and extrication of oxygen and of carbonic acid gas, by night and by day; the decomposition of water; the descent of the cambium, and its conversion into wood and bark; and, lastly, the primary principles of which plants consist, or to which they may be reduced—carbon, oxygen, hydrogen, azote. Further, he leans to the opinion of the ameliorating influence of vegetation on the air of the atmosphere, as originally advanced by Priestley;—an opinion that was formerly much and keenly controverted, but that has obtained, notwithstanding, the sanction of the most eminent chemists of the present day. Such is our brief sketch of the origin, progress, and present state of phytology.

PILEUS.—The pileus or cap is the conical or umbrella-shaped organ that surmounts the stipe of the Agarics, and supports the gills. See FUNGI.

PISTIL.—The pistil is a small and column-shaped, but often pestle-shaped, organ, occupying almost invariably the centre of the flower, and encompassed immediately by the stamens,—that is, when the

plant is hermaphrodite. In monœcious and diœcious plants this arrangement cannot take place. The pistil is simple, as in the Cherry, or compound, as in the Pear; and it is divisible at least into two, but very often into three, distinct parts,—namely, the ovary, the style, and the stigma. The ovary is the lower extremity of the pistil, supporting the style and stigma, and containing the rudiments of the future seed or seeds. [See OVARY.] The style, or middle portion of the pistil, is a prolongation of the substance of the ovary, issuing generally from its upper extremity, and supporting the stigma. It is deciduous, and falls when the ovary is ripe; or persistent, and adheres to the fruit. The stigma is a small and glandular-looking substance crowning the style, and hence also denominated the summit. Yet it is sometimes, though rarely, lateral, as in *Scheuchzeria*. Its figure is globular, or hemispherical, or conical, or petaloid. It is destitute of an epidermis, and in its duration it is, like the style, sometimes deciduous and sometimes persistent.

According to the doctrine of the morphologists, the pistil, if simple, is a metamorphosed leaf, or carpellum, as in the pea; if compound, it is a combination of metamorphosed leaves or carpella, which, when two in number, are opposite, as in Wall-flower; and when more than two in number, are associated in a whorl, as in the Lily. Upon this principle the ovary is the expansion of the leaf, together with the space enclosed by the folding of that expansion from the midrib inwards, till the margins meet, and form by their junction the placenta; the style is a prolongation of the midrib; and the stigma is its discoloured apex. If the carpella of a compound pistil remain distinct, as in *Caltha*, they are said to be *apocarpous*; but if they are united into one body, as in *Pyrus*, they are then said to be *syncarpous*.

PITH.—The pith is a soft and spongy, but often succulent substance, occupying the centre of the root, stem, and branches of Dicotyledonous plants, and extending in the direction of the longitudinal axis, in which it is enclosed as in a tube. In most plants it is close and compact, without any apparent solution of continuity, as in the Willow and Poplar; but in others it is loose and interrupted, as in the Thistle and Walnut. In the Fig and Elder its diameter is large in proportion to that of the stem or branch; while in the Oak and Elm it is but very small. Its structure is similar to that of the pulp, being composed of an assemblage of hexagonal cells, containing in its young state a watery and colourless juice. Mirbel regards the cells as being furnished with pores for the transmission of fluids; but Dutrochet denies their existence, and contends that the fancied pores are merely minute molecules imbedded in the walls of the cells like those of the pulp, which he designates by the name of nervous corpuscles. [Rech.

Anat. 13.] He affirms, besides, that there is no pith in the root, and in this he is followed by Professors Lindley and Henslow. Yet, notwithstanding the sanction of these high authorities, the evidence of a multitude of instances compels us to come to a very different conclusion. In the majority of dicotyledonous roots, we admit, there is no visible pith, at least at a certain age; but let any one examine the root of *Berberis communis*, and if that does not exhibit a pith, let him inspect with care the root of seedlings of the Oak, Ash, Beech, and Sycamore (*Acer Pseudoplatanus*), and above all that of the common Hazel-nut-tree, *Corylus Avellana*, and then let him say what he thinks of the affirmation of Dutrochet; for we affirm, *au contraire*, that there is a palpable pith in the root of many plants, even of those called dicotyledonous, at least in the earlier stages of their growth, as the cutting open of the root of the above seedlings will evidently show.

The pith is usually described as being altogether insulated, and unmixed with any other organs; yet it must be admitted that it is not always entirely so. In the older branches of the Elder, and even in the annual shoot, in the course of the winter, I have often found longitudinal fibres passing through the whole extent of the pith. They seemed to be imbedded in its surface, and were easily detected by their brown and rusty colour. This I took to be the commencement of the process described by M. Mirbel, by which the pith is at last all but wholly obliterated; but I find that this doctrine is not now orthodox. The popular writers say that the pith undergoes no further diminution after it dries up, which is at the end of the first year of its growth, but retains nearly its original dimensions even in the matured wood. [Lind. Introd. 60.] I have proof sufficient to show that this is not the fact. Further, I have found in the young shoots of the Elder, spiral vessels that seemed to be imbedded even in the pith itself; but it is certain that Dr. Brown has detected their existence in the pith of the several species of *Nepenthes*.

Much has been said concerning the function of the pith, and many opinions hazarded. In the earlier ages of phytological enquiry, or rather in ages when phytological opinions were taken up without enquiry, one of the vulgar errors of the time seems to have been an opinion that the function of the pith was that of generating the stone of fruit, and that if a plum-tree were to be deprived of its pith, it would produce fruit without a stone. This opinion receives some countenance from Evelyn [Pomona, chap. i.], but we presume that it is now exploded. Another early opinion is that by which the pith was regarded as being analogous to the brain and heart of animals; though we cannot see in what respect it is analogous to either. Malpighi

believed it to be, like the cellular tissue, the viscera in which the sap is elaborated for the nourishment of the plant, and the protrusion of future buds. Magnol thought that it produces the flower and fruit, but not the wood. Duhamel thought it was not destined to perform any important function at all in the vegetable economy ; and Linnæus revived the old doctrine of its analogy to the brain and spinal marrow. Thus all was uncertainty or contradiction among the earlier phytologists, with regard to the function of the pith ; and we believe that no function has been yet assigned to it, even among modern phytologists, calculated to do away all doubt.

Mr. Knight, in one of his papers published in the Philosophical Transactions for 1801, regards it as destined by nature to be a reservoir of moisture to supply the leaves when exhausted by excess of perspiration ; which opinion Sir J. E. Smith combated, contending that the cause assigned is wholly inadequate to the effect, as the moisture of the pith would in many cases be insufficient to supply even one hour's perspiration of a single leaf. Thus he overthrows the hypothesis of Mr. Knight ; but we cannot think that he succeeds in establishing his own, which is merely a modification of that of Linnæus, by which he regards the pith not as a source of nourishment, but as a reservoir of vital energy or life, analogous to the spinal marrow or nerves of animals. Yet surely the analogy will not hold good. If the spinal marrow is injured, the parts below are immediately paralyzed ; and if it is broken, the animal dies ; but Mr. Knight, after Theophrastus, has shown that a portion of the pith may be abstracted from the shoot, so as to occasion a disruption of continuity, without doing any material injury to the plant.

Hence it appears that the peculiar function of the pith has not yet been altogether satisfactorily ascertained ; and the difficulty has been thought to be increased from the circumstance of its seeming to be only of a temporary use in the process of vegetation, by its disappearing altogether in the aged trunk. But although it is thus only temporary as relative to the body of the trunk, yet it is by no means temporary as relative to the process of vegetation ; the central part of the aged trunk being now no longer in a vegetating state, and the pith being always present in one shape or other in the annual plant, or in the new additions that are annually made to perennials. The pith then is essential to vegetation in all its stages ; and from the analogy of its structure to that of the pulp or parenchyma, which is known to be an organ of elaboration, as in the leaf, the function of the pith may probably be that of giving some peculiar elaboration to the sap, or of aiding in the protrusion of buds, according to the hypothesis of Malpighi, which has been revived of late years by M. Du Petit Thouars,

and has, with some modifications, received the sanction of Dutrochet also. In addition, M. Dutrochet regards the cells of the pith as containing multitudes of corpuscular globules, or molecules of nervous matter endowed with a peculiar vitality, calculated to forward the process of vegetation, and to expedite the developement of the several organs. [L' Agent. Immed. 43.]

PLACENTA.—That portion of the Ovarium in which the ovula originate is called the placenta. It generally occupies the whole or a portion of one angle of each cell, being formed by the union of the folded-in margins of the carpellary leaf.

PLANT.—A plant or vegetable is a living and organized body, insentient, and incapable of locomotion; but originating in a seed which springs up into a plant again producing seed. See DEFINITION OF THE PLANT.

PLANTLET.—The plantlet is that portion of the embryo which is invested, or partially invested, by the cotyledons; being the future plant in miniature, or seat of seminal life.

PLUMELET.—The plumelet is that portion of the embryo which corresponds to the *Caudex ascendens* of Linnæus, being a minute and sometimes feather-like production, crowning the summit of the infant plant. This term is usually written *Plumule*, the use of which I uniformly avoid, on account of a cacophony in its pronunciation which is to my ear offensive. But I suppose it is not offensive to the ears of others, for no one adopts *Plumelet*, though it is perfectly legitimate in its formation. See DISSECTION OF SEEDS.

POISONS.—As plants, like animals, are living and organized beings, susceptible to the action of stimuli, and dependent for their existence upon the elaboration of aliment, it was to be expected that poisons or irritants injurious to the life of the one, might be injurious also to the life of the other. Hence the experiments of M. Marcet of Geneva, with a view to ascertain the fact.—1st. Two or three plants of the common Kidney Bean, with five or six leaves each, were watered with a solution of oxide of arsenic. At the end of from twenty-four to thirty-six hours the plants were fading, and the leaves drooping and turning to yellow. They never more recovered.—2nd. A lilac-tree was killed in the course of six weeks, in consequence of the introduction of from fifteen to twenty grains of moistened oxide of arsenic into a slit in one of the branches.—3rd. Other mineral substances injurious to animals were found to be equally injurious to vegetables; but mineral substances innocuous to animals were found to be innocuous to vegetables also.—4th. Vegetable poisons produce the same fatal effects upon plants as upon animals. Plants of the Kidney Bean taken up out of the earth and immersed by the root in water were found

to remain healthy for six or eight days. But a plant that was so taken up and immersed in a solution of *nux vomica* at nine o'clock in the morning was affected as follows: At ten it seemed unhealthy; at one the petioles were all bent in the middle; and in the evening it was dead. Prussic acid produced death in twelve hours, and laurel water in six or seven.

From the above data M. Marcet deduces the following conclusions:—1st. Metallic poisons act upon vegetables nearly as they do upon animals. They appear to be absorbed and carried to the different organs of the plant, corroding and destroying the vessels through which they pass. 2nd. Vegetable poisons which have been proved to destroy animals, by their action on the nervous system, are found also to destroy plants; whence M. Marcet seems to infer the existence of a system of organs in vegetables analogous to that of the nerves of animals. His facts have been confirmed by the experiments of Macaire; and his conclusions thus rendered more plausible still, as well as more apparently corroborative of M. Dutrochet's doctrine of the existence of nervous molecules.

POLLEN.—The pollen is the fine powder that is contained in the anther or summit of the stamens, which, when the flower is mature, explodes, very generally of its own accord, and spontaneously discharges its contents. In the flowers of the Cypress, this fine powder is thrown out with such force, and in such abundance, as to make it resemble a cloud of smoke; and the mature flowers of the birch and willow, if suddenly shaken with the hand, will exhibit a similar phenomenon. The colour of the pollen is very generally white; but sometimes it is yellow or orange, and sometimes it is blue or red, as in *Verbascum*. Its particles are of various forms—oval, globular, cylindrical, angular. The pollen of the *Fuchsiae* is a very beautiful microscopic object; its particles being, in their form, triangular; in their colour, of a bright white; and in their aggregate, cohering together by small threads. But the particles of all descriptions of pollen are themselves organized bodies, as may be seen with the assistance of a good microscope, consisting of a thin and membranaceous bag, extremely susceptible to the action of moisture, which, as soon as it meets with, it explodes, like the anther itself, and discharges a fine and subtle vapour, or a sort of fluid in which there are contained globules or molecules still smaller. The discharge of the primitive globules may be seen by placing an anther of *Equisetum* upon a bit of white paper, and watching it till it bursts; and the discharge of the secondary globules may be readily seen by placing on water an anther of *Valerian* with its pollen.

Hedwig regarded the cuticle of the globules as consisting of a single

membrane. But as Koelreuter, Gærtner, and M. Ad. Brongniart regard it as consisting of a double membrane, we may safely adopt as correct this view of the subject. We cannot say quite so much for M. Brongniart's opinion with regard to the minute molecules which are thrown out when the pollen explodes. According to him, they are animated substances; the analogues of the spermatic animalcules of Leuenhoeck, and their animality is inferred from the agility of their movements.

Dr. Brown who followed in the tract of Brongniart, found the descriptions of his predecessor to be sufficiently correct. But he prosecuted the subject to a much greater length. He extended his researches even to the molecules of unorganized matter,—the scrapings of rocks, or of stones,—pounded glass,—soot; and found that they all exhibited similar movements when suspended in pure water. It is a startling fact, to be sure, if these movements are to be regarded as indications of vitality, as was formerly done by Fray. But Dr. Brown is too cautious to draw that hasty conclusion, though it does seem to follow from some unguarded expressions that had escaped him at first. But taking his reformed, and corrected, and deliberate opinion [See ACTIVE MOLECULES], as in fairness we ought to do, it amounts merely to an affirmation of their perpetual motion without assuming their animality. It is difficult, indeed, to account for that motion upon any principle short of animality; and yet there are physiologists who think that it must, after all, proceed from extrinsic causes. [Raspail Nouv. Syst. 173.] But in this opinion Dr. Brown does not acquiesce; and thus the phenomenon remains now,—as it was in the beginning, and ever will be,—a mystery.

The above account of the pollen, and of its discharge from the anthers, will be found to be sufficiently applicable to the great mass of Phænogamous plants. It rests on the ground of cautious and correct observation, and shows how the pollen of such plants may have easy access to the summit of the pistil or stigma. Yet there are some peculiar orders of vegetables—the *Orchideæ* and *Asclepiadææ* in particular, that present singular anomalies, and singular difficulties to embarrass the investigator, whether his object is that of ascertaining the structure of the anthers themselves, or the mode in which their contained pollen is conveyed to the style. To the earlier phytologists this was an absolute riddle, except in so far as it might be done through the instrumentality of insects. Not that they had altogether neglected the investigation; but that the result of their investigations presented but a mass of conflicting opinions, from which no satisfactory conclusion could be drawn. In this state the subject remained, till at last it attracted the notice of several of the most

eminent physiologists of the present day, among whom we will particularize the names of Bauer, Brown, Ad. Brongniart, and Ehrenberg, whose investigations, though not issuing uniformly in the same results, have dissipated so palpably the obscurity that overhung the subject, and narrowed so much the extent of debatable ground, that all future researches must be rendered comparatively easy. See the article **FECUNDATION**.

POLLEN TUBES.—The pollen tubes, which are equivalent to the *boyaux* of M. Ad. Brongniart, are tubes of an extreme tenuity which issue from the innermost of the two membranes that invest the globule of pollen, and elongate as the result of their contact with the stigma, till they pass down through the pistil, and ultimately reach the *ovula*, which they enter by the micropyle, and to which they thus conduct the impregnating fovilla of the pollen. Yet Dr. Lindley says he has not been able to discover two membranes in any *really simple* pollen that he has examined, adding that “in *Gesneria bulbosa* there is incontestably but one membrane.” [Introd. to Bot. 133.]

POLYGAMOUS PLANTS.—Plants producing male, female, and hermaphrodite flowers, indifferently, are said to be polygamous.

POMUM.—The pomum is a fleshy or pulpy pericarp or fruit without valves, but enclosing a capsule, which is a thin and membranaceous substance, consisting for the most part of five distinct cells. It is exemplified in the familiar case of the apple, from the Latin appellation for which, it has taken its name.

PORES.—Pores are openings or presumed openings in the membrane composing the cellular or vascular tissue of the interior of the plant. Mirbel advocates the doctrine of their existence, and Dutrochet denies it. See the article **CELLULAR TISSUE**.

POTASH.—If the ashes of vegetables burnt in the open air are repeatedly washed in water, and the water filtered and evaporated to dryness, potash is left behind. It is white and semi-transparent, and is extremely caustic, and deliquescent. It dissolves all soft animal substances, and changes vegetable blues into green. It dissolves alumina, and also a small quantity of silex, with which it fuses into glass by the aid of fire. See the article **ALKALIES**.

PRICKLES.—Prickles are stiff and sharp-pointed processes issuing from the stem or branch, and originating in the bark, with which they may be entirely stripped off. In this respect they differ from thorns, which have their origin in the wood. They are well exemplified in the Rose or Bramble.

PRIMARY PRINCIPLES OF VEGETABLES.—From the analysis of the vegetable subject as exhibited by chemical experimenters, it is evident that the compound ingredients or proximate principles of vegetables

are all ultimately reducible to a very few uncompound elements or primary principles, and that the most essential of such compounds consist of carbon, oxygen, and hydrogen, together with a small proportion of nitrogen, said to occur chiefly in cruciform plants. If there be any other primary principles, they seem to be dependent in a great measure on soil and situation : whereas the elements of carbon, oxygen, and hydrogen, form as it were the very essence of the vegetable subject, and constitute by their modifications the peculiar character of the properties of plants. This is conspicuously exemplified in the result of the investigations of MM. Gay Lussac and Thenard, who have deduced from a series of the most minute and delicate experiments the three following propositions, which they have dignified with the appellation of laws of vegetable nature.

1st. Vegetable substances are always acid when the oxygen which they contain is to the hydrogen in a greater proportion than in water.

2nd. Vegetable substances are always resinous, or oily, or spirituous, when the oxygen which they contain is to the hydrogen in a smaller proportion than in water.

3rd. Vegetable substances are neither acid nor resinous, but saccharine or mucilaginous, or analogous to woody fibre or to starch, when the oxygen and hydrogen which they contain are in the same proportion as in water. [Tract. de Chim. Elem. tom. iii. chap. 3.]

Perhaps the induction of particular proofs is not yet sufficiently complete to warrant the above conclusions in their fullest extent. But enough has been established by the above or by other chemists to satisfy the scientific enquirer that the closest analogy exists between several compounds that differ widely in their sensible qualities, as well as to elucidate several processes in nature and in art, by which certain vegetable substances are convertible, by very slight modifications, into one another. Hence an additional proof of the great power and wisdom of the Creator, who, from a few simple and primary elements combined in peculiar proportions, educes all that variety and profusion of compound substances which the vegetable kingdom exhibits, as adapted to the use of man.

PRIMINE.—The outermost of the coats that envelope the ovulum in its early state, has been by Mirbel denominated the *primine*; and botanists seem to have adopted the term. See DEVELOPEMENT OF THE VEGETABLE OVULUM.

PROPAGO.—According to Gærtner, the propago is a simple gem reproductive of certain genera of Cryptogamous plants, particularly the Lichens. It is a small and pulpy granule of no regular shape, naked, or covered with an envelope, and equivalent to the spores of modern botanists.

PROPER JUICES.—The proper juices of vegetables are peculiar and special juices, secreted by appropriate organs, and abounding in certain plants, as well as lodged in proper receptacles, *les vaisseaux propres*, or infiltrated into the tissue, but not apparently for nutrition. They differ in different species by their consistence and colour, and are to be held as distinct from the *Cambium*, which is destined peculiarly to nutrition. In the Fig, the proper juice is white; but in Celandine it is yellow; while in the former it is mild, and in the latter caustic. But one of the most remarkable species of juices called proper, is that of the Cow-tree, palo de vaca—*Galactodendron utile* [Kunth] of the Cordilleras of South America. It is a white and balmy, and very nutritious fluid, resembling milk. It exudes from incisions made in the bark, and flows most copiously about sun-rise, when the natives may be seen going with bowls, or other suitable vessels, to catch it; as the milkmaids of this country go with their pails in their hands to milk their cows in the morning. [Lardner's Encyc.]

PROLIFEROUS FLOWER.—If a flower protrudes other flowers from within in its own disk, it is said to be proliferous, as in Childing Daisy.

PROXIMATE PRINCIPLES OF VEGETABLES.—The proximate principles of vegetables are those compound materials which present themselves to the experimenter on the first and most simple analysis of the vegetable body. The methods of the first analysts were often injudicious from want of scientific views, and the analysis imperfect from want of proper instruments. Hence the results of their investigations were often also contradictory, and the conclusions deduced from them erroneous or absurd. But whatever may be the view or success of the experimenter, the method which he employs must be either mechanical or chemical.

The mechanical processes are such as are effected by the agency of mechanical powers, and are often, indeed, the result of the operation of natural causes. For it sometimes happens, that of the ingredients contained in a plant part becomes insulated, extricating itself from the organ in which it was formed or elaborated, and detaching itself of its own accord. Hence the origin of gums and other spontaneous exudations. But the substances thus obtained do not always flow sufficiently fast to satisfy the wants or necessities of man. Hence men have contrived to accelerate the operations of nature by means of artificial aid, in the application of the wimble, the axe, or the knife. The plant bleeds now more freely, and the substance wanted is obtained in abundance; whether it is the gum of the cherry-tree, the resin of the fir, the manna of the ash, the opium of the poppy, or the sap of the birch or maple.

Yet it more frequently happens that the process employed is wholly artificial, and altogether effected without the operation of natural causes. When the juices are lodged in parts that are isolated, or may easily be isolated, the vesicles may be opened by means of rasps or graters, and the juices expressed by the hand, or by some other fit instrument. Thus the volatile oil may be obtained, that is lodged in the rind of *Citrus medica* or of *Cedrela odorata*. When the substance to be extracted lies more deeply concealed in the plant, or in parts that cannot be easily detached from the rest, it may then become necessary to pound or to bruise the whole, or a great part of a plant, or to subject it to the action of a press. Thus the fixed oils may be obtained that are lodged in seeds or in fruits. The heterogeneous ingredients which must thus be mixed together, may generally be separated with tolerable accuracy by means of decantation; or, if that fails, by means of filtration, the best and simplest mode of separating feculent matters.

The chemical processes are such as are effected by the agency of chemical powers, and may be reduced to the four following:—1st. The action of water or of alcohol, by infusion, digestion, or decoction, forming a solution that is afterwards to be evaporated to dryness, and subjected to the proper tests. 2nd. The action of acids, or of alkalies, as being the most powerful of chemical solvents. 3rd. The agency of distillation, expelling the volatile principles of the plant by sublimation, or in the form of permanently elastic or condensable fluids, and leaving an earthy, an alkaline, or a carbonaceous residuum. Lastly, the agency of combustion, dissipating entirely the volatile principles of the subject of analysis, and leaving a residuum of ashes.

These processes are much more intricate in their nature than any that are merely mechanical, as well as more difficult in their application. Their accuracy, which must at all times have depended upon the state of chemical knowledge, could not at an early period have been very great. Further, it appears that the principal errors of the earlier analysts arose chiefly from the defects of their chemical apparatus, each having a different result to record from the same apparent process. Hence Davison's definition of a chemist, as related by Ray, "*Animal credulum et mendax*." [Hist. Plant. lib. i. 46.] But this imputation, more witty than wise, was soon wiped off. New adventurers arose, introducing new modes of analysis, and converting even the errors of former experimenters to their advantage. Boulduc, Herman, and Cartheuser, may be mentioned among the first of the new investigators in the field of vegetable analysis; who were succeeded by Beccaria and Kessel-Meyer; who were afterwards followed by Rouelle and Bucquet, who gave a precision to the process of

analysis that tended most materially to throw light upon the subject. Finally, from the application of pneumatic chemistry as introduced by Priestley, extended by the profound investigations and important discoveries of Lavoisier, and further advanced by the researches of Ingenhouz and Senebier, as also from the experiments of Vauquelin, Proust, Pelletier, Chaptal, Deyeux, Saussure, with those of Thomson and Davy, and, lastly, of Gay Lussac and Thenard, the vegetable analysis has attained to a degree of perfection surpassing all previous calculation, and beyond which it cannot perhaps be carried very far.

The proximate principles of vegetables are so very numerous in themselves, or so much diversified in their qualities, as to have rendered it necessary for chemists to adopt some definite and specific plan of arrangement, in order to give method and precision to the subject, and accordingly different writers have adopted different plans. But as our plan is merely alphabetical, we have nothing to say on this subject, but to add that the following proximate principles, *cum quibusdam aliis*, will be found in their proper places:—Acids, albumen, alkalies, ashes, balsams, bitter principle, cãutchouc, camphor, charcoal, colouring matter, cork, earths, extract, fibrin, gluten, gum, gum-resins, metallic oxides, narcotic principle, oils, proper juice, resins, starch, sugar, sap, tannin, wax, woody fibre, or lignin.

PRUSSIC ACID.—This acid is generally ascribed to the animal kingdom, because it is obtained in greatest abundance from animal substances, particularly from bullock's blood. But it has been proved to exist in vegetable substances also; and may be procured by distilling the leaves of the Laurel—*Laurus nobilis*; or of *Prunus Lauro-cerasus*; or the kernels of the peach and cherry, or of bitter almonds. When pure it exists in the form of a colourless fluid, with an odour resembling that of Peach-tree blossoms. It does not redden vegetable blues. It has been introduced into medicine, but with no very satisfactory result. It is a deadly poison.

PUBESCENCE.—Pubescence is a general term including all sorts of cuticular processes or prolongations with which the surface of the plant may be covered, finer or less formidable than the armature, such as hairs, hooks, scales, down.

PULP.—The pulp is a term that may be regarded as synonymous with that of the Cellular Tissue, to our description of which we refer the reader.

PULVINUS.—M. Link has given the name of *pulvinus* to the small protuberance that is found on the stem or branch, immediately under the cicatrice which the leaf leaves behind by its fall.

PUTAMEN.—The putamen of Gærtner, which is equivalent to the

endocarpium of Richard, is the shell of the nut, or the stone of the Drupe, as exemplified in the Filbert and Peach. It does not open spontaneously.

PURPLES, OR BROWN PURPLES.—There is a disease incident to our crops of wheat that is known in Kent by the name of *Brown Purples*, which attacks, not a whole ear, but individual grains; distorting the normal shape of the clevel, and tinging it of a purple or dark-brown colour. In 1807, M. Francis Bauer, having had some infected ears sent him, undertook the examination of the grains thus diseased; and after much minute microscopical investigation, found himself warranted to draw the following conclusion,—namely, that the fibrous substances found in the distorted grains are real, organized, worm-like animals, which may already exist in the grain, or may enter the germinating seed-corn by absorption, either in the worm or egg state,—a process rendered probable from his successful inoculation of sound grains, with worms taken from infected grains, which were nourished and propelled by the ascending sap till they ultimately reached the incipient ear. These worm-like little animals are found to belong to the genus *Vibrio*,—*Vibrio Tritici*, and are so very tenacious of life, that, though kept in a dry or dried state for several years, they will revive again upon being exposed to the action of moisture. But the steeping of the seed in lime water, before sowing, is an effectual preventive. [Phil. Trans. 1823.]

PYRENA.—If a putamen is composed of several cells, each cell takes the name of pyrena, as in *Cornus*.

PYXIDIUM.—The pyxidium is a one-celled capsule, which has become so by the obliteration of the dissepiments of several carpella, and in which the suture of dehiscence is transverse to that of the valves, as in *Anagallis arvensis*.

QUARTINE.—If the chorion or nucleus of the ovulum develops a secondary integument, it is, according to Mirbel, to be called the *quartine*.

QUASSINE.—When water is digested for some time over quassia, its colour becomes yellow, and its taste intensely bitter; and if it is evaporated to dryness, it leaves behind a substance of a brownish yellow, with a slight degree of transparency, that continues for a time ductile, but becomes afterwards brittle. This substance Dr. Thomson regards as the bitter principle in a state of purity. [Syst. of Chem. vol. iv. 242.] In the nomenclature of the present day it has obtained the appellation of Quassine.

QUININE.—This alkaloid, which is obtained in the shape of a powder, was first extracted from the bark of Cinchona by MM. Pelletier and Caventou. It is soluble in alcohol, but insoluble in water. It is

decomposed by heat. It does not crystallize, but it forms neutral salts with all the acids. It is much used in medicine under the form of a sulphate, and in cases of ague is held to be quite a specific.

QUINTINE.—If the amnios, or transparent drop of fluid that appears in the centre of the vegetable ovulum after fecundation, is invested with a peculiar integument, that integument, according to M. Mirbel, is to be called the *quintine*, that is, if the chorion has already developed a quartine.

RADICLE.—The radicle is that portion of the embryo which in germination descends into the soil, and becomes the root, or caudex descendens, of Linnæus.

RACEME.—The raceme is merely a different term for that mode of inflorescence which is called the Cluster—which see.

RACHIS.—The flexuose axis of the inflorescence of the grasses is denominated the rachis, and the term is also applied to denote the midrib of the Frond of Ferns.

RAMENTA.—The small and scattered scales that are frequently found on the stems of vegetables, originating in the bark, and giving it a rough or chopped appearance, were by Linnæus denominated *ramenta*. They are peculiarly conspicuous on the stem or branches of *Tamarix gallica*.

RAPHE.—The raphé is the internal umbilical cord, which passes from the hilum or base of the seed to the *chalaza*.

RAPHIDES.—The raphides are small and needle-shaped substances, interspersed throughout the cellular tissue, or proper juices of many plants. They are said to be crystals of oxalate of lime. [Raspail.]

RAYS.—The divergent layers seen on the transverse section of the stem of woody plants are often designated by the appellation of the medullary rays. The outer petals of a compound radiate flower are also designated by this name.

RECEPTACLE.—With botanists, the receptacle is the base on which the several parts of the fructification rests; that is, the extremity of the peduncle, which undergoes many modifications in accommodating itself to the form of the flowers and fruits of the different families of plants.

RED GUM.—There is a malady incident to our crops of wheat that is known to the farmer under the name of red gum. It attacks the ear only, and is extremely prejudicial to the crop, destroying the individual grains entirely in which it is found, and converting them into a group of red, minute, and glutinous globules, interspersed with transparent fibres. The globules are filled with a fine powder, which explodes when they are put into water. From this it might be thought

that they are the sporules of some species of intestinal Fungus; but they seem, after all, to be but globules of starch or of pollen in a morbid state. For as the injured grain generally contains a small yellow maggot, the larva perhaps of *Tipula Tritici*, the disease is doubtless occasioned by the puncture of the gnat or fly in the depositing of its egg, which it lays in the very centre of the nucleus, which swells into a morbid mass till it bursts, without being able to effect the normal developement of its parts, that are thus promiscuously blended together, and tinged with the colouring matter of the pollen like the maggot that feeds upon them. This disease was very prevalent in the Dengie hundred of Essex in 1812, and lessened materially the value of the wheaten crop, a great proportion of ears being injuriously affected.

RED RUST.—Another malady incident to our most useful grains is that which is known by the name of Red rust. It assumes the appearance of a rusty-looking powder, and soils the fingers when touched. On the 25th of March, 1807, I examined some blades of wheat that were attacked with this disease. The appearance was that of a number of rusty-looking spots or patches dispersed over the surface of the leaf, exactly like that of the sporules of Dorsiferous Ferns, bursting their *indusium*. Upon more minute inspection these patches were found to consist of thousands of small globules collected into groups beneath the epidermis, which they raised up in a sort of blister, and at last burst. Some of them seemed as if embedded even in the longitudinal vessels of the blade. They were of a yellowish or rusty brown colour, and somewhat transparent. M. Decandolle regards them as being the sporidia of *Uredo rubigo*, a species of his own creating; but as it attacks the stem and leaves only, it does not materially injure the crop.

REGENERATION OF BUDS.—It has been shown, at the article BUD, that the buds which expand in spring are generated in the preceding summer, and augmented and prepared for developement in the intervening winter. But if the buds are destroyed in the winter, or in the early part of the spring, many plants will again generate new buds that will develop their parts as the others would have done, except that they never contain blossom or fruit. By what means are the buds regenerated?

Duhamel thought that they sprang from pre-organized germs, which he conceived to be dispersed throughout the whole of the plant. He took cuttings of the willow and stuck them in the earth, making them, at the same time, to pass through a barrel filled with earth, so as to have a portion exposed to the air between the earth and the barrel, and another portion projecting beyond the surface of the mould with

which the barrel was filled. The part inserted in the soil produced roots, and the part passing through the earth contained in the barrel produced roots also ; but the other two portions produced branches. Hence he concluded that germs, both of the root and branch, are dispersed throughout the whole of the plant, and developed as the exigency of the case requires.

Mr. Knight thinks he has discovered the true source of the regeneration of buds in the proper juice that is lodged in the alburnum. If the stalk of *Crambe maritima* is cut off near the ground in the spring, the pith within that part of the stalk which remains still attached to the root, rots, and a cup is formed that collects water in the succeeding winter. The sides of the cup consist of a woody substance, which resembles the alburnum of trees, and new buds are often seen to be protruded from within the cup in the following spring. Further, in the spring of 1802 Mr. Knight raised a number of plants from seeds of the Apple, Pear, and Plum, which he cut down in the autumn to the collar, exposing at the same time part of the root. In the following spring a number of small protuberances were observed on the bark of the exposed roots, which were found to be occasioned by minute processes issuing from the alburnum : they were incipient buds. Experiments made upon the stem and root of aged trees gave the same result, establishing, as Mr. Knight thinks, the position that the alburnum possesses the power of organizing and of regenerating buds.

This theory does not differ much from that of Duhamel. It merely confines the organizing power to the alburnum, while Duhamel seems to extend it to the whole plant. M. Du Petit Thouars has a theory by which he derives all buds from the shoot or pith of the first year, giving them from that time a horizontal direction, by which they are propelled through all the succeeding and annual layers, and are always found in the alburnum ready to be developed when wanted. See the article BUD.

REGENERATION OF LEAVES.—Sometimes the leaves of a tree are destroyed partially or totally as soon as they are protruded from the bud, by the depredations of caterpillars, or of other insects, or by the browsing of cattle. In the case of a small Roan-tree that had been totally stripped of its leaves by the browsing of a cow, new leaves were soon afterwards produced by the protusion and development of the axillary buds, though the tree had been transplanted both early in that spring, and in the spring preceding. The new shoots were but short, but the leaves were ultimately of about the usual size. Some trees will bear to be stripped even more than once in a season, as the White Mulberry-tree, which they cultivate in the south of France and Italy, for the purpose of feeding the silk-worm. But

if a tree is stripped more than once in a season, it requires now and then a year's rest.

REGENERATION OF BARK.—The decortication of a plant, or the stripping it of its bark, may be either intentional or accidental; partial, or total. If it is partial, and affects the epidermis only, it is again regenerated, as in the case of slight incision, without leaving any scar. But if the epidermis of the leaf, petal, or fruit is destroyed, it is not again regenerated, nor is the wound healed up except by means of a scar. Such is the case also with all decortications that penetrate deeper than the epidermis, particularly if the wound is not protected from the action of the air. But if the decortication reaches to the wood, then the wound will not heal up in the foregoing manner at all. Duhamel inflicted a wound of this description in the spring, to the extent of a few square inches. In the course of a few days there appeared issuing from the lip of the wound, as if from between the wood and bark, a ring of new bark, which became broader and more solid in the summer, lessening the area of the original wound. At the end of the summer it was found that a new layer of wood was formed under this bark; and in the following year a new ring of bark was generated concentric to the former, and also a new layer of wood beneath it; and so on successively, approaching the centre of the wood, till at last the whole area of the wound was covered, but without any actual union of the old and new wood. Such is the process of nature in healing up wounds of the bark.

REGIONS.—If there be any extensive districts of the earth's surface separated from other districts by some grand physical feature, hostile to further dispersion—such as a chain of mountains, or a wide sea, and hence inhabited by but few species in common with contiguous districts, though situated in the same parallel of latitude, such districts are called botanical regions. Botanists have already enumerated at least forty such regions—as the Arctic, the European, the Caucasian, the Tartarian, the Siberian, the Indian; and seem to be in a fair way of discovering many more. If a species is found to be peculiar to any given region, then that region is its habitation. See **HABITATION**.

REGMA.—If a pericarp consists of three or more cells which burst from the axis with elasticity into two valves, it is called a regma, and the several cells are called *cocci*. It is exemplified in *Euphorbia*. [Lindley.]

REPLUM.—When the two sutures of a Silique separate from the valves, they form a kind of frame called *replum*, as in *Cheiranthus*.

REPRODUCTIVE ORGANS.—Organs whose functions regard specifically the propagation of the species, in opposition to those which regard merely the growth and nourishment of the species, are by

some phytologists denominated Reproductive Organs. M. Burnett calls them *generants*.

RESINS.—Resins are substances somewhat resembling gum, at least in their external appearance, and often exuding spontaneously from the plant that contains them. They are exemplified in the common *rosin* of the shops, and are regarded as holding the same relation to volatile oils, as wax holds to fixed oils. They are, in short, volatile oils rendered concrete by means of the absorption of oxygen, or rather perhaps by the abstraction of part of their hydrogen.

They are either soft and viscous, or solid and brittle, with a slight degree of transparency, and a yellowish colour. Their taste is somewhat acid, but they are without smell when pure. Their specific gravity varies from 1.018 to 1.228. They are non-conductors of electricity, and when excited by friction their electricity is negative. They are insoluble in water, but most of them are soluble in alcohol. When exposed to heat they melt, burning with a strong yellow flame, and evolving a great deal of smoke. The products of their destructive distillation are carburetted hydrogen, carbonic acid gas, a small portion of acidulous water, and much empyreumatic oil. They are extremely numerous, like the oils from which they are formed; but the following, which will be found in their proper places, are the most distinguished:—rosin, mastic, sandarach, elemi, tacambac, labdanum, opabalsamum, copaiva, dragon's blood, guaiac, botany, bay-resin, green resin, copal, animé, lac.

RESPIRATION.—The alternate inhalation and extrication of oxygen and of carbonic acid gas, in the night, and in the day, as effected by the leaves of vegetables, is by some physiologists denominated their *respiration*; and it must be admitted that the evident analogy existing between the respiration of animals, and the process in question, is a sufficient apology for the introduction of the term. See **ELABORATION OF CARBONIC ACID, AND OF OXYGEN.**

RINGENT COROLLA.—When the two lips of a labiate flower are separated from each other by a wide and regular orifice, the corolla is said to be *ringent*.

ROOT.—The root is that part of the plant by which it attaches itself to the soil in which it grows, or to the substance on which it feeds, and is the principal organ of nutrition. This definition is perhaps as comprehensive as any one that can be given, whether with regard to perfect or to imperfect plants; though it is no doubt liable to many exceptions, if made to apply to both; for even of plants denominated perfect some are found to float upon the surface of the water, having their roots immersed in it, but not fixed,—such as the several species of *Lemna* or Duck-meat; and of plants denominated imperfect, some

have no root at all, or at least no visible part distinct from the rest, to which that appellation can be ascribed, such as many of the *Confervæ*; or they are apparently altogether root, such as *Tuber cibarium* or Truffle.

There are also many of the imperfect plants which attach themselves to other vegetables, and to vegetable or other substances, from which they cannot be supposed to derive any sort of nourishment whatever, owing either to the mode of their attachment, or to the character of the substances to which they attach themselves. Such are many of the Mosses, Lichens, and marine plants found adhering to the outer and indurated bark of aged trees, to dead or decayed stumps, to rotten pieces of wood, and frequently to rocks, or to stones.

These, therefore, are to be regarded as exceptions to the rule; which includes, however, parasitical plants, strictly so called, which have generally occasioned some difficulty; for although parasitical plants are not found to attach themselves to the earth or soil, but to some other living vegetable, as the *Viscum* or Mistletoe to the Oak or to the Apple-tree; yet it is from the plant to which they attach themselves that their nourishment is derived.

But almost all plants of the perfect class are fixed in the earth by a root descending in species of a large growth, and sometimes even in species of a smaller growth, to a considerable depth below the surface, and spreading by means of lateral divisions to a considerable extent around the centre. The divisions of the root of the Baobab or African Calabash-tree have been known to measure upwards of one hundred feet in length.

As roots have been found to exhibit a considerable variety of shape, size, and structure, they have accordingly been found to be of particular utility in the discriminating of species, and have been distributed for the convenience of botanists, and for the sake of giving precision to botanical description, into several different sorts, of which the following are the principal:—the spindle-shaped root, the bitten root, the fibrous root, the bulbous root, the tuberous root; each of which will be found to form an article in its due place.

ROOTSTOCK.—The rootstock—rhizoma—“is a prostrate thickened rooting stem which yearly produces young branches or plants. It is chiefly found in the *Irideæ* and epiphytous *Orchideæ*” [Lindley], and in some Ferns.

ROTATION OF CROPS.—It had been observed, even in the earliest period of agriculture, that some crops operate peculiarly as exhausters of the soil.

“Urit lini campum seges, urit avena;
Urunt lethæo perfusa papavera somno.”

[VIRG. GEOR. Lib. i. 77.]

But although a soil may be exhausted for one sort of seed or grain, it does not necessarily follow that it is exhausted also for another. Hence the enlightened agriculturist sows his crops in rotation, knowing that if this system is judiciously followed up, the whole of the manure is employed, and that those parts of it which are not fitted for one crop remain as nourishment for another. Suppose the rotation to be turnips, barley with seeds, and wheat; the soluble portion of the recent manure affords a ready nourishment for the turnips, and the land being but little exhausted by this crop, yields the now soluble part of the decomposing manure to the barley. The seeds come up in their turn, and take but little of the organized matter from the soil. At the end of two years they are ploughed in, when the decay of their roots and leaves affords additional nourishment for the wheat crop; after which, fresh manure is again applied, and the rotation begins anew. [Davy's Agri. Chem. 320.]

RUNNERS.—Runners are young shoots issuing from the collar or summit of the root, and creeping along the surface of the soil, but producing a new root at the extremity, and forming a new individual, by the decay of the connecting link. This takes place in a great variety of herbs, but particularly in the Strawberry, which is a good example.

SACCULUS COLIQUAMENTI.—By this appellation Malpighi designated the fine, thin, and pellucid membrane with which the amnios is found to be sometimes invested. It seems now to be called the *embryonic sac*.

SAFFRON.—The substance which is denominated saffron, is merely the summits of the pistils of flowers of the genus *Crocus*—the only genus of vegetables whose stigmata are found to be odorous, if those of *Anthoxanthum odoratum* are not also so. It is obtained in the greatest abundance from the pistils of *Crocus sativus*; and, when perfectly pure, consists of stigmata only. But from the high price which it bears in the market it is often adulterated with a mixture of stamina. As a medicine it is aromatic, and stimulant; but it is now chiefly valued for its colouring matter, being of a fine and bright yellow, to which chemists give the name of polychroite.

SAGO.—If the pulp or pith of the stem of *Metroxylon sagus*, of *Cocos nucifera*, or of almost any other species of palm, is taken out and pounded, and then mixed with cold water, it will after a while deposit a sediment which is separated by decantation. It is the starch which the pith contained, or the *Sago* of the shops.

SALEP, OR SALOOP.—The tubers of the Orchideæ were regarded by the ancient simplists as possessing very singular and powerful proper-

ties, chiefly aphrodisiacal. They are known, however, to contain a great deal of farinaceous and most nutritious matter; very palatable, and certainly very portable; if it be true, as it is said, that an ounce a day is sufficient to support human life. In London this substance used formerly to be manufactured into a sort of drink, which was a favourite beverage with porters and coal-heavers. It was known by the name of salep or saloop, the Persic term for Orchis; and in Turkey and Persia it is in high repute still.

SALTS.—Most plants are found by analysis to contain a certain proportion of earthy or of alkaline salts. How do plants acquire them? Are they formed in the process of vegetation; or are they absorbed in solution from the soil; and if so absorbed, are they absorbed as a vegetable food? For the solution of these questions, see the article **FOOD OF PLANTS**.

SAMARA.—This term was employed by Gærtner to denote a species of capsule which is described as being indehiscent, winged, one or two celled, but without valves; as in the Ash, Elm, and Maple.

SANDARACH.—This resin is obtained from *Juniperus communis*, or common Juniper, by spontaneous exudation. It concretes in the form of small round tears, somewhat brownish and semi-transparent, and resembling mastic. It is used chiefly as a varnish.

SAP.—If a branch of the vine, *Vitis vinifera*, is cut asunder early in the spring, before the leaves have begun to expand, a clear and colourless fluid will issue from the wound, and will continue to flow copiously for a considerable length of time. It is merely, however, the ascending sap, and may be procured from almost any other plant, by the same or similar means, and at the same season; but particularly from the maple, birch, and walnut-tree, by means of boring a hole in the trunk. It issues chiefly from the tubes of the alburnum, though, in some plants, it does not flow freely till the bore is carried to the centre. A small branch of a vine has been known to yield from twelve to sixteen ounces in the space of twenty-four hours. A maple-tree of moderate size yields about two hundred pints in a season; and a birch-tree has been known to yield, in the course of the bleeding season, a quantity equal to its own weight.

The taste of this fluid is generally insipid; but sometimes it is slightly saline, and sometimes agreeably sweet, as in the case of the Birch-tree. If exposed to the action of fire, it emits bubbles of carbonic acid gas, exhales a strong odour of vinegar, and yields by distillation carbonate of ammonia. It combines in all proportions with water, which dilutes and dissolves it when thick and viscid. Alkalies combine with it readily, and saturate its excess of acid. In the sap of *Fagus sylvatica* Vauquelin found the following ingredients:—

water, acetate of lime with excess of acid, acetate of potass, gallic acid, tanin, mucous and extractive matter, and acetate of alumina. [Ann. de Chim. vol. xxxi. 20.]

Hence it is plain that the sap consists of a great variety of different ingredients, though there is too little known concerning it to warrant the deduction of any general conclusion, as the number of plants whose sap has been hitherto analyzed is yet but very limited. It is the grand source of vegetable aliment, and may be regarded as being somewhat analogous to the blood of animals; but not thoroughly so, till it is converted into cambium. It is not made use of by man, at least in its natural state. But there are trees, such as the birch, whose sap may be manufactured into a very pleasant wine; and it is well known that the sap of the American Maple yields a very considerable quantity of sugar.

SARCOCARP.—The sarcocarp is the fleshy pulp that lies between the external cuticle, and the putamen, or shell of stone fruit. See **PERICARP**.

SCALES.—The term scales or squamæ is usually applied to designate the bractæ of amentaceous flowers; or indeed the bractæ of any flower, if they have a scaly appearance.

SCAPE.—The scape is a flower-stalk issuing immediately from the root, and forming the only trunk of the plant. It is well exemplified in the case of the several species of *Primula*. It is naked, as in the Hyacinth; or scaly, as in *Tussilago Farfara*; or leafy, as in Sweet-Flag.

SCAMMONY.—This substance or gum-resin is the produce of *Convolvulus Scammonia*, a native of the Levant. The root or root-stock, when cut into, yields a milky juice that concretes on exposure to air, and forms the drug known by the name of scammony. It is a violent cathartic.

SCUTELLA.—The little shields or cups found on the *thalli* of the Lichens, are by botanists designated scutellæ.

SECONDINE.—The interior integument of the seed that lines the testa of Gærtner and immediately envelopes the chorion or nucleus of the ovulum, is by M. Mirbel denominated the *Secondine*.

SECRETION AND SECRETIONS.—Secretion is the function of a living organ, which it discharges by virtue of a capacity of selecting from the general mass of nourishment such particles or portions as are necessary to its individual wants, or available to the purposes of the economy of the species; as also of rejecting and ultimately expelling from the system such particles or portions of the general mass of nourishment as are not necessary to its own individual wants, nor available to the purposes of the economy of the species. Hence

secretion is a vital function, and the secreting organs are the glands, cells, or membranes of which the plant is composed.

But secretions are the matters secreted; which, upon the principle of the above definition, are either—recremental, that is, retained in the system,—or excremental, that is, thrown out of the system. The recremental secretions are the proper juices, the resins, the gum-resins, the oils, the acids. The excremental secretions are the waxy, nectarous, or saccharine exudations that issue from the leaf, flower, or fruit; or, finally, the gummy and extractive exudations that are deposited by the root. The details of such of these matters as possess any thing of importance, will be found in their proper places.

SEED.—The seed, which is the last and most noble part of the fruit, is the interior portion of the ripened ovary, contained within the pericarp, and containing the rudiments of a new plant similar to that from which it sprang. In the pea and bean, it is that part of the fruit which is eaten. In the apple and pear, it is that part which is rejected, and lodged within the core. Seeds, like bulbs, are extremely tenacious of potential life. If well preserved from the action of the atmosphere, they will retain their vitality for many years. But it has been said that they will retain it for thousands of years. Among the mummies lately unswathed in this country, one was found, as it is affirmed, to grasp in its hand a few grains of Egyptian wheat; which, when put into the soil, germinated, and grew, and sprang up, as if they had been but the produce of the year preceding. I ought to add that I have only a newspaper authority for this fact; and I am sorry to say that I have not been able to find a better. See the articles FRUIT and FERTILITY OF PLANTS.

SENSATION.—Sensation, as applied to animals, is that peculiar property by which they are rendered susceptible to pain or to pleasure from the impression of external objects. This property has been claimed for plants also; and the claim will be discussed under the head of the SUSCEPTIBILITIES OF VEGETABLE FABRICS.

SEPALs.—The several divisions of the calyx which had not till lately a proper name, are now called *Sepals*.

SEPTICIDAL.—A mode of the dehiscence of fruits. See PERICARP.

SEPTIFRAGAL.—A mode of the dehiscence of fruits. See PERICARP.

SEXUALITY OF VEGETABLES. — The doctrine of the sexuality of vegetables, and fecundation of the Linnæan system, though but lately established upon the basis of logical induction, is by no means a novel doctrine. It cannot, however, be said that the original notion of a sexual distinction, as existing in plants, was at all correct. It was a conjecture formed at random, rather than an opinion founded upon the evidence of fact; which maintained its ground, however, for a

period of many ages, though wholly unsupported by any convincing argument, till at last the elucidations of Linnæus established it beyond a doubt.

It cannot now be ascertained with whom, or at what particular period, the notion of vegetable sexuality originated. But its antiquity is unquestionably great; as it appears to have been entertained even among the original Greeks, from the antiquity of their mode of cultivating figs; and to have been made the subject of the speculations of some of their earliest philosophers, from the fact of its having been a doctrine taught by Empedocles that the sexes are united in plants. Herodotus recognises the doctrine in his account of the cultivation of *Phoenix dactylifera* or the Babylonian Palm, which he represents as being cultivated in the country around Babylon in the manner of figs, the cultivator taking the flower of what the Greeks call the male Palm, and binding it around the flowers of the female, or fruit-bearing Palm, that the fruit may thus ripen, and not fall immature. [Herod. Pors. Clio, 193.] Thus we have proof of the prevalence of the notion, at least in the age of Herodotus—that is, 400 years before the Christian Æra.

Our next authority is that of Aristotle, who maintains the doctrine of a distinction of sex in plants as well as in animals, though he admits that some plants are altogether without sex; and represents the beneficial effect of the practice adopted in the cultivation of the Palm, as resulting from the action of the dust of the male flower, quickening the maturity of the fruit, which it is said to effect also equally well if it is but wafted to the female flower by means of the wind. [Περὶ γένεσεως Ζωῶν. το Α.]

Theophrastus, the disciple and successor of Aristotle, who pursued his phytological speculations to a much greater length than his master, maintains also the doctrine of the sexuality of vegetables, which he illustrates in the case of a variety of trees, but particularly in that of the Palm. If the spathe of the male plant containing the male flowers is cut off, and shaken over the flowers of the female plant, the fruit does not fall, but is preserved till it is mature; in which case, he adds, there is a sort of coitus—μίξις of the male and female. [Περὶ φυτ. ιστορ. Β.]

After a long blank in the annals of phytological research, the next traces of enquiry relative to the sexuality of vegetables are such as occur in the works of Pliny, Dioscorides, and Galen, who also adopted the division by which plants were then distributed into male and female; but chiefly upon the erroneous principle of habit, or of aspect, and without any reference to a distinction absolutely sexual; the fertile plant being sometimes denominated the male, and the barren

plant the female; as in the example of male and female mercury, in which the true notion of vegetable sexuality was altogether reversed.

Cæsalpinus, who follows next in order, though not till after an interval of many centuries, enters more into the detail of the doctrine, and speaks with more confidence on the subject than any preceding phytologist. Trees which produce fruit only he denominates females, and trees of the same species which are barren he denominates males; adding that, where the males grow in the neighbourhood of the females, the fruit is better and more abundant, owing to certain exhalations issuing from the males, which, by an operation not to be explained, disposes the females to produce more perfect seed. Still it seems doubtful whether any conjecture had been yet formed with regard to the peculiar and appropriate organs by which the sexual intercourse is conducted, or whether the idea of sex was yet extended to hermaphrodites.

At last, however, about the middle of the seventeenth century, when the improved philosophy of Bacon had begun to be adopted even in phytology, and phytologists to be directed by observation and experiment, rather than by hypothesis and conjecture, the doctrine of the sexes of plants began also to assume a more fixed and determinate character, and to exhibit the legitimate evidence of being founded upon fact, as well as of its applicability to the case of the hermaphrodites.

Malpighi, who describes not only the stamens and anthers, but also the pollen contained in them, regards the former as excretory organs, and the latter as the substance excreted. He may be said to have failed, therefore, in assigning to the pollen its true function. But the merit of suggesting its true function seems to lie between Sir T. Millington, Savillan Professor of Astronomy at Oxford, and the celebrated Dr. Grew, who represents the suggestion as originating with the Professor, and consisting in the expression of an opinion that the stamens serve as the male organs of the vegetable, for the generation of the seed, in which opinion he immediately acquiesced. This we may regard as the first glimpse that was ever caught of the true and proper use of the stamens, and may date at about the year 1676. According to Grew, their function is discharged as follows:—When the anthers surmounting the filaments burst open in the process of vegetation, the enclosed pollen falls upon the pistil and impregnates the embryo, not by actually entering the pistil, but by means of a subtle and vivific *effluvium* which it sheds upon it. Hence stamens are the male, and the pistil or pistils the female organs of vegetable impregnation. [Grew's Anat. b. iv. c. 5.]

Ray seems to have been the first convert to this novel doctrine;

but Camerarius was the first to institute experiments with a view to its illustration ; from which he inferred that the generation of plants is analogous to that of animals, the male and female organs being the stamens and pistils respectively. Then followed the experiments of Geoffry, and then the experiments of Vaillant, all of which led to the same conclusion.

But though the doctrine of the sexes of vegetables was thus daily acquiring new accessions of proof, yet it was destined to receive its last degree of elucidation from the pen of Linnæus. This great and illustrious botanist, reviewing with his usual sagacity the evidence on which the doctrine rested, and perceiving that it was supported by a multiplicity of the most incontrovertible facts, resolved to devote his labours peculiarly to the investigation of the subject, and to prosecute his enquiries throughout the whole extent of the vegetable kingdom ; which great and arduous enterprise he not only undertook, but achieved with a success equal to the unexampled industry with which he pursued it. So that, by collecting into one body all the evidence of former discovery or experiment, and by adding much that was original of his own, he found himself at length authorized to draw the important conclusion, that no seed is perfected without the previous agency of the pollen, and that the doctrine of the sexes of plants is consequently founded in fact. The enquiries on which this conclusion rests were made by Linnæus about the year 1732, and are summarily included in the following brief induction of particulars,—first as resulting from observation, and secondly as resulting from experiment.

Observation 1st.—In all plants hitherto discovered it has been observed that the fruit is uniformly preceded by the blossom, and that without blossom there is no fruit. Every schoolboy knows that unless the Cherry-tree blossoms in the spring, he will gather no fruit from it in the summer.

Obs. 2nd.—The fruit-bearing individuals of such species as have their barren and fertile flowers on distinct plants, do not perfect their fruit except where individuals of both sorts are stationed in the vicinity of one another. To the truth of this the ancients bore testimony in their manner of cultivating the Palm and Fig-tree.

Obs. 3rd.—If the stamens or pistils are obliterated by cultivation, or injured by rain or frost, or by the operation of any other natural cause, the process of impregnation is interrupted, and the fruit deteriorated in quantity or in quality. This fact is well known both to farmers and to gardeners.

Obs. 4th.—The pollen is generally discharged from the anther in such a manner as to ensure its dispersion, at least to any pistil that is

near it, and at such a time as pistils of the same species are best fitted to receive it. The Cypress-tree throws out a little cloud of pollen; and almost all plants discharge it about the time when the stigma is mature.

Obs. 5th.—The relative proportion, situation, and mutual sympathies of the stamens and pistils are such as seem expressly calculated to facilitate the process of impregnation. In pendulous flowers the pistils are the longest, as in the Lily; and in upright flowers the stamens are the longest, as in *Ranunculus*. In the genus *Saxifraga* the stamens bend down to the pistils, one or two at a time, and discharge the pollen directly over the stigma.

Obs. 6th.—The economy of many of the aquatics seems also expressly intended to facilitate the process of impregnation. Why else do they rear their heads above the water, as in the case of *Valisneria spiralis*, about the time when the flowers are ripe, and then sink down to the bottom to ripen and to sow their seeds?

Experiment 1st.—If the anthers of a hermaphrodite flower, or the stameniferous flowers of a monœcious plant, are cut off before they shed their pollen, and care taken to prevent the access of the pollen of any other plant of the same species, the fruit will prove abortive. A gardener who stripped his melons and cucumbers of all their stameniferous flowers as soon as they made their appearance, thinking that they but exhausted the nourishment that was due to the female flowers, found, to his great mortification and dismay, that he had in the end no fruit at all.

Exper. 2nd.—If, after the anthers have been removed, as in the foregoing experiment, the pollen of another plant of the same species is shaken over the pistil, then the fruit will still ripen. This Linnæus proved in the case of *Chelidonium corniculatum*.

Exper. 3rd.—If the stigma of the pistil is cut off before the discharge of the pollen, or if the stigma is merely covered with some suitable integument, no fecundation ensues, and the fruit is inferior both in quantity and quality. This experiment was made by Perotti, with the above result. [Decand. Phys. Veg. 508.]

Exper. 4th.—If the stigma of a flower that has been stripped of its stamens before the bursting of the anthers, is sprinkled with the pollen of a plant of a different species of the same genus, then the seeds will not only ripen and produce perfect plants when sown, but the plants will partake of the qualities of both the fecundating and fecundated species. Hence the origin of hybrids.

Exper. 5th.—If a male plant is placed in the vicinity of a female plant, which, from being formerly insulated, had produced no perfect seed; or if the pollen of a male plant is conveyed to it from a dis-

tance, and sprinkled over the stigma, it will now produce perfect seed. The noted experiment of the Berlin Palm, by Linnæus, affords the best example of the conveying of the pollen; and that of M. de la Serre's Pistacia-tree of the result of the presence of the male plant. [Duhamel, Phys. des Arb. liv. iii.]

Exper. 6th.—If the male plant is again removed from the vicinity of the female plant to which it had given fecundity, the fruit of that female is again produced imperfect as before. When M. de la Serre's male plant was again removed, the seeds of the female plant were again found to be incapable of germination; and the experiments of Linnæus upon *Clutia tenella* give the same result.

Such is the amount of the great body of evidence, whether resulting from observation or from experiment, on which Linnæus established the doctrine of the sexes of plants, and on which the important and irresistible conclusion depends—namely, that no seed is perfected without the previous agency of the pollen. Yet this doctrine was still so novel, and so contradictory to the previous prejudices of the majority of botanists, that a host of adversaries was immediately in arms against it; some fighting for truth, as we may believe, but others confessedly for victory. The most distinguished of the opponents of the doctrine were Tournefort, Pontidera, Alston, Spallanzani, Smellie. We do not enter into the detail of this literary warfare, or of the animus with which it was waged. We content ourselves merely with stating that the opponents of Linnæus were all silenced in succession, either by Linnæus himself or by his followers, and the doctrine of vegetable sexuality so firmly established that no one now ever thinks of calling it in question. See Keith's Physiological Botany.

SHEATH.—This term is applied to designate a sort of sack-like envelope that invests the base of the fructification of the mosses, as also a circle of fibres that invest the pith longitudinally, and is usually designated by the name of the medullary sheath.

SHRUB.—If the branches of a perennial proceed immediately from the *caudex descendens* without any intervening trunk, the plant is called a shrub, as in Privet.

SILICA.—The greater part of the Grasses contain a considerable portion of silica, as do also the plants of the genus *Equisetum*. It resides chiefly in the epidermis; and hence such plants are sometimes used to give a polish to surfaces where smoothness is required. The Dutch Rush is used to polish even brass.

SILICULA.—If the transverse and longitudinal diameters of a silique or silique are equal, or nearly so, it then takes the name of a *silicula*, as in *Thlaspi*.

SILIQUEA.—The silique is a dry and elongated pericarp or fruit, con-

sisting of two valves with two opposite seams to which the seeds are alternately attached, as in *Cheiranthus*. When the valves open they separate from the seams, and form a *replum*, with a dissepiment, which is sometimes fenestrate.

SKELETONS.—Vegetables, owing to the peculiar and specific structure and connexion of their parts, are not so well adapted as animals to be converted into skeletons. You may char your vegetable, or you may subject it to the process of petrification, but still you have not made a skeleton of it. In short, vegetables have not that proportion of soft parts which is necessary to the operation; nor that internal and symmetrical fabric of hard parts which will still cohere as distinct organs, even when the softer parts have been dissipated or detached. Yet there are certain organs belonging to vegetables that may be converted into skeletons after all.

The leaves of many plants admit of being converted into skeletons; and are in fact so converted in the very process of their natural decay, as they lie rotting in the recesses of the grove or forest; so that if you wish to meet with skeletons already prepared to your hand, you have only to search for them in such localities; but if not, then you may succeed by the application of artificial means,—namely, that of maceration in water. The epidermis of the two surfaces, together with the contained chromule, perishes entirely in the process, and leaves nothing behind but the net-work that has been formed by the anastomosing of the fibres. This, even in the leaf of the Oak, Elm, and Beech, which consists of two layers, presents a most beautiful skeleton; but in that of the Orange, which consists of three layers, the beauty as well as delicacy of the skeleton is without a parallel.

SLEEP OF PLANTS.—As light acts upon leaves as a stimulant, so darkness, or the absence of light, acts as a sedative. Thus it is known that the leaves of many plants assume a very different position in the night, from what they have had in the day. These positions are not the same in the case of all leaves that sleep. They differ with the species in which the change of position takes place. Simple leaves that sleep are affected in their totality. Compound leaves that sleep are not always affected in their totality, but only in some of their parts.

Of simple leaves some,—*the opposite*, meet by the bending in of their petioles, and sleep face to face, as in *Atriplex*; some,—*the alternate*, by the folding in of their edges, so as to embrace the stem, and cover the flower in their axil, as in the Mallows; and some by the bending down of the leaf-stalk, so as to cover the flowers below, as in *Impatiens*.

Of compound leaves, some are trefoils, and some winged, forming

the ground of a primary division. Of trefoils, some bend their leaflets so as to bring the base and summit nearly into contact, leaving a cradle-like cavity in the middle, which sometimes protects the flowers, as in *Trifolium incarnatum*. Some bend them by the lower half, and leave the summit divergent, as in the Melilots; and some bend them down so as to face by their inferior surfaces, as in *Oxalis*. Of winged leaves, some erect their leaflets, so as to meet above the petiole, face to face, as in *Colutea*. Some bend them down so as to meet below the petiole by their under surfaces, as in *Acacia*. Some fold them up, above and along the common foot-stalk, so as to overlap one another, in a direction looking to the summit of the petiole, as in the genus *Mimosa*, in which there is this singularity, that while the leaflets bend up, the main petiole bends down. Lastly, the leaflets of *Tephroisa caribæa* fold up and overlap like those of *Mimosa*, but in a direction looking to the base of the petiole. [Decand. Phyto. Veg. 857.]

Physiologists find it difficult to assign an adequate cause to account for the above phenomenon. This effect seems to be produced partly by the agency of moisture, as it is known to be accelerated by dews and rains, and to be even occasioned by artificial watering. But of the cause of the specific modes of folding up, as exhibited in different genera, we can affirm nothing for certain; though we may regard the leaves that fold themselves up in the night as requiring an interval of rest, which they thus obtain after having been exposed throughout the day to the *stimulus* of light. Upon this principle Linnæus has, not without propriety, designated the above phenomenon by the appellation of the Sleep of Plants.

SLIPS OR CUTTINGS.—If a shoot is detached from a branch, and placed in the soil, it will, in many cases, still continue to vegetate. It is called a slip or cutting. It succeeds well in currants, vines, and willows.

SMUT.—Smut is a disease incidental to cultivated corn, by which the farina of the grain, together with its proper integuments, and even part of the husk, is converted into a black soot-like powder. If the injured ear is struck with the finger, the powder will be dispersed like a cloud of black smoke; and if a portion of the powder is wetted by a drop of water, and put under the microscope, it will be found to consist of countless multitudes of minute and transparent globules, which seem to be composed of a clear and glary fluid, encompassed by a thin and skinny membrane. It is now universally regarded as a *fungus*, to which botanists give the name of *Uredo segetum*. According to the calculations of Mr. F. Bauer, it would require 7,000,000 of the globules to cover a space equal to one square inch; and according to the calculations of M. Fries, each globule may be regarded

as containing at least 10,000,000 of sporules. How do the spores find their way into the plant? Mr. Bauer, with Mr. Fee and others, is of opinion that they first float in the air till wetted, then sink into the soil, where they are absorbed by the roots of the plants on which they are found, along with the nourishment which the root takes up, and ultimately conveyed to the ear through the channel of the sap-vessels. [Burnett's Outlines, 184.]

Yet this disease does not affect the whole body of the crop, though the smutted ears are sometimes very numerous dispersed throughout it; neither does it affect the sample that is carried to market, because it is effectually blown away in the cleaning. Hence the buyer knows nothing of it, and the flour is uninjured. But besides the disease called smut, there is also a disease analogous to it, originating in a fungus, known to the botanist by the name of *Uredo foetida*, and to the farmer by the name of bags or smut-balls, in which the *nucleus* of the seed only is converted into a black powder, whilst the ovary, as well as the husk, remains sound. The ear is not much altered in its external appearance, and the diseased clevels contained in it will even bear the operation of thrashing, and will consequently mingle with the bulk; but they are always readily detected by the experienced buyer, and fatal to the character of the sample; for being ultimately broken by the operation of grinding, they mingle infallibly with the flour, and communicate to it a black colour that injures its sale. The practice of the miller is to wash the grain before grinding, and to skim off the diseased clevels which float on the surface. Both diseases are said to be prevented by washing the seed to be sown in lime-water.

SOILS.—Writers on agriculture have distributed soils into the several following varieties:—the sandy, the gravelly, the clayey, the chalky, the loamy, the peaty, the alluvial.

A sandy soil consists almost entirely, or at least principally, of small grains of silica, or the earth of Flints, neither cohering together, nor soluble in water or acids. According to Sir H. Davy, this term ought not to be applied to any soil containing less than $\frac{7}{8}$ of sand. It is not an eligible soil, owing to the risk of sand-floods, by which what you sow in one field you may have to reap in the next.

A gravelly soil consists of a congeries of small and irregular-shaped stones—flinty, gravelly, or calcareous, together with other rocky substances, partially decomposed. It is not an eligible soil for the agriculturist.

A clayey soil is a soil in which clay predominates, or exists in some considerable proportion. It is beyond all other soil tenacious of moisture. In its wet state it is tough and sticky as mortar. In its dry state it turns up in large lumps or clods; but wheat, beans, oats, clover,

tares, may all be cultivated to great advantage upon a clay soil, if properly managed.

A loamy soil is more tenacious than sand, but less tenacious than clay. It contains much of vegetable mould, and is the most eligible of all soils for the purpose of husbandry, being friable in a high degree, and capable of cultivation at all seasons of the year.

A chalky soil consists chiefly of some calcareous substance, mixed with such other ingredients, clayey or siliceous, as chance may have thrown in its way. It is better fitted for tillage than for pasture.

A peaty soil consists chiefly of vegetable aquatics, in a state of partial decomposition, together with vegetable or other mould or materials washed down by rains from the surrounding heights. It is not of itself a fertile soil.

An alluvial soil consists of the sediment of streams or of estuaries mixed with decayed or decomposed vegetable substances. The fine and rich meadows that are found by the sides of rivers—the Carse of Scotland and the Salt Marshes of England are covered with an alluvial soil—level, deep, and fertile, and adapted in its texture and composition to the culture of the most valuable crops.

SOREDIA.—Soredia are heaps of powdery bodies that lie scattered upon the surface of the *thalli* of the Lichens.

SORI.—The clusters of spores or granules that are found on the fronds of Dorsiferous Ferns are denominated *sori*.

SPADIX.—The spadix is a species of inflorescence in which the flowers are closely arranged around a fleshy axis which is enclosed in a spathe. It is peculiar to the Palms and Aroideæ.

SPATHE.—The term spathe is by some botanists restricted to the floral leaf that invests the spadix of the Palms and Aroideæ. By others it is extended to the sheath that invests the unexpanded flowers of Narcissus and similar liliaceous plants.

SPECIES.—A species is a group of individuals connected together by certain obvious and unequivocal resemblances, in the form and structure of their several parts or organs, but differing by some striking and peculiar trait from all the other groups of allied individuals that may happen to belong to the same or to any other genus.

SPIKE.—The spike is a species of inflorescence consisting of an assemblage of flowers arranged in close succession upon a common and longitudinal axis; which is generally a prolongation of the stem, as in Wheat and Barley.

SPINDLE-SHAPED ROOT.—If a root tapers gradually from the base to the apex, and descends to a considerable depth in the soil, it is said to be spindle-shaped, as that of the Carrot or Parsnip.

SPINES.—The leaves or their segments, as well as the divisions of

the calyx, are in many plants found to terminate in sharp indurated points, which may be called *spines*, as in the Thistles, particularly in that species which the Scotch have adopted as emblematic of their nation. Hence the origin of the motto,—*Nemo me impune lacessit*.

SPIRAL VESSELS.—The spiral vessels are fine, filmy, and transparent tubes, interspersed occasionally with the other tubes of the plants, but readily distinguished from them by their being twisted in the form of a corkscrew, from right to left, as in the stem of Spearmint, or from left to right, as in the stem of Fuller's Teasel, and terminating in a cone, as it is said. Grew and Malpighi, who first discovered and described them, represented them as resembling in their appearance the *tracheæ* of insects, and designated them by that name—an appellation by which they are still very generally known.

They do not occur often in the root, or, at least, they are not easily detected in it, though Kieser is said to have found them in it, in great abundance. [Sup. Encyc. Brit. Veg. Anat.] Dutrochet could find none, and denies their existence in the root expressly. [L'Agent Immed. 20.] For myself, I can safely affirm that I have repeatedly met with them in the root of the Lettuce called Cos Lettuce, though not in any other root that I have ever examined in search of them. Neither are they to be found in the branch or stem of woody plants, except in the annual shoot; nor in the pith of any plant, except in the several species of *Nepenthes*. [Phil. Mag. Oct. 1832, p. 317.] But in the stem and branches of herbaceous plants they are generally to be found without much difficulty, accompanying the longitudinal fibres, and forming part of the bundles. They are very easily detected in the foot-stalk, whether of the leaf or flower. They are discoverable also in the leaf itself; though rarely in the calyx and corolla; and more rarely still in the other parts of the flower. Grew and Malpighi found them both in fruits and seeds. I have myself met with them in the external umbilical cord of the seed of the Cherry, at a very early period of its growth,—that is, about the time of the falling of its petals,—but not in any other fruits. In the leaf or leaf-stalk of the Artichoke the spirals are not only remarkably large, but also remarkably beautiful, exhibiting the appearance of spiral coats investing interior fibres, rather than that of a distinct and individual tube, and seeming, when uncoiled, to be themselves formed of a net-like film, consisting of three principal and longitudinal stripes. [Keith's Phys. Bot.] At present we find that the botanical adepts are divided on this subject, one party contending that the spires are external to the tubes as they appeared in the case just stated; and the other party contending that the spires are, on the contrary, internal, forming a lining to the tubes, and not a coating. Dr. Brown, 'as we learn, espouses the

former opinion, and Professor Henslow, as we see, espouses the latter. [Lardner's Cab. Cyclop.]

Is it certain that the organs now under consideration are tubes? In the closely coiled up state in which they exist in the growing plant, they might be said to constitute tubes by the union of their spires. Divide a leaf-stalk of the Artichoke or of the Elder longitudinally, cutting it partly, and tearing it partly asunder, and place a portion of it under the microscope. Inspect the exposed surface of it carefully and in a strong light, and it will present to your view bundles of spirals in their coiled up and united state. Divide a portion of the same leaf-stalk transversely, cutting it partly, and breaking it partly asunder. Place it under the microscope in a clear and strong light, and multitudes of spirals, not yet divided, but merely drawn out, and partly uncoiled, will be found to connect the fractured surfaces; and if you stretch them even till they give way, the fragments will, as if by an elastic and inherent spring, coil themselves up again, nearly as before; yet the prevailing opinion seems to be that the spire does not in any case constitute a tube, but forms merely a coating or lining to a tube within it, or without it.

Much has been said with regard to their functions. Malpighi regarded them as destined to the transmission of air. Grew thought they transmitted not only air, but sap. Mirbel regards them as being well fitted for the transmission of the ascending sap. [Defence de Ma Theorie, 221.] Mr. Knight thinks they are altogether incapable of transmitting moisture. Yet Hedwig and Senebier concurred in affirming that a fluid may be seen issuing from their orifices, if the horizontal section of a stem is inspected immediately after its division. Hence they are doubtless capable of conducting a fluid, whether it be the ascending sap or not. The latest hypothesis with regard to their function is that of M. Dutrochet. He shows that they cannot be the channel of the sap's ascent, because they do not exist either in the root or stem, except as aforesaid—that is, in the annual shoot. He shows also that they contain a fluid *sui generis*—that is, a diaphanous fluid, which is neither air nor sap. He infers that their function is in accordance with that of the leaves, because it is in the leaves that they occur in the greatest abundance. But leaves are vegetable lungs, and as animals receive a vivifying influence from oxygen in the lungs, so plants, through means of the leaves, receive a vivifying influence from the light of the sun, either directly or in combination with the fluids they contain; which influence the spirals or tracheæ convey to the interior, and are hence to be regarded as *organs of insolation*. [Recher. Anat. 31.]

SPONGIOLÆ.—The pulpy and bibulous extremities of the fine fibres

of the root are called spongiolæ, from their absorbing, like little sponges, the moisture of the soil. They are composed of one or more central ducts or vessels, enveloped by a cellular tissue, but they are destitute of an epidermis.

SPORES.—The small gems or granules by which plants of the class Cryptogamia are propagated, and which are lodged in the Soredia, or Sporidia, botanists designate by the name of spores or sporules. Fries counted in a single plant, or globule, or *sporidium* of the smaller sort of smuts, *Uredo segetum*, ten million of sporules, so fine and so subtle as to ascend into the atmosphere like smoke. Hence the facility with which they are dispersed over the surface of the whole globe. The rapidity of their increase is altogether astonishing, whether they remain disunited and in a powdery mass, or are aggregated into a definite form. A Phallis has been known to grow to the height of six inches within an hour. The *Bovista gigantea*, or Bull puff-ball, has been known to grow at the rate of a million of additional cells per second. Hence the enormous and irresistible force with which these tender plants expand, overthrowing or pushing before them all impediments, even to the removal of stones of great weight. At Basingstoke, in Hampshire, two mushrooms, by the mere force of vegetation, though not remarkably large, heaved up a huge paving stone of upwards of 80lb in weight, to the height of an inch and a half beyond the level of the pavement. [Burnett's Outlines, 239.]

SPORIDIA.—The fine and filmy envelopes that enclose the sporules of the Fungi are denominated *sporidia*.

SPUR.—The spur is a horn-like process issuing immediately from the corolla, as in Orchis. Linnæus regarded it as a nectary, but it does not always contain a nectariferous gland.

STAMENS.—The stamens, an appellation borrowed from the Latin term *stamen*—a thread—

“Et gracili geminas intendunt *stamine* telas”—OVID. MET. vi.

are substances of a very slender fabric, and of a thread-shaped figure, consisting of two parts,—namely, a filament and an anther—that is, a small bag, or *viscus*, which the filament supports. They are situated immediately within the corolla, to which they are sometimes attached, and may be seen very conspicuously by opening up the blossom of a Tulip or of a Lily. They are apparently of no importance in the eye of the vulgar spectator, but are essential to the botanical notion of a flower, because indispensable to the formation of perfect fruit. The calyx is sometimes wanting, and the corolla is sometimes wanting; or the calyx and corolla both, as in Euphorbia; but the stamens are never wanting, except through adventitious or accidental causes

united. Linnæus suggested a rule for distinguishing the calyx from the corolla, founded upon the position of the stamens. The stamens alternate with the segments of the corolla, but face the segments of the calyx. This rule holds good in many cases, but is not universal. They face the corolla in the Lily, unless, with Jussieu, we call the single envelope a calyx. [See MORPHOLOGY.] Sometimes the stamens cohere by the filaments; if in one set, they are monadelphous; if in two sets, they are diadelphous; if in more than two sets, they are polyadelphous. Sometimes they cohere by the anthers, as in the nineteenth class of Linnæus, and then they are said to be syngenesious. See articles FILAMENT, ANTHER.

STANDARD.—The upper petal of a papilionaceous flower, which is generally large, with an erect border, is denominated the standard.

STARCH.—If a quantity of wheaten flour is taken and made into a paste with water, and kneaded and washed under the action of a jet till the water runs off colourless, part of it will be found to have been taken up, and to be still held in suspension by the water, which will by and by deposit a sediment, that may be separated by decantation. This sediment is starch.

Starch thus obtained is a fine and white powder, without any palpable taste or smell. If thrown upon water, it swims for a time upon the surface, but mixes with it at last, and forms, with cold water, a kind of emulsion, and, with boiling water, a thick paste. If thrown upon redhot iron, it burns with a kind of explosion, and leaves scarcely any residuum behind. If a few of its grains or globules are put upon the stage of a good microscope, and wetted with a drop of the watery solution of iodine, the observer will see their white colour changing first to purple, then to violet, and then to blue; but the original colour is restored by the addition of an alkali. M. Raspail regards them as being already organs elaborating a gummy substance within their cells, in the same manner that other cells elaborate oils or resins.

According to the analysis of Gay Lussac and Thenard, the composition of starch is as follows:—carbon 43.55, oxygen 49.68, hydrogen 6.77. This result is not very widely different from the analysis of sugar, into which it is known that starch may be converted by diminishing the proportion of its carbon, and increasing that of its oxygen and hydrogen. Such is the change that takes place in the malting of barley.

The seeds of all our esculent grains contain starch, as well as those of wheat, and so do also both the root and stem of many other plants. From the pulpy stem of the palms we have Sago; and from the tubers of the Orchideæ we have Salep; and it is very well known that much starch is manufactured out of potatoes, as also that the principal in-

redient of vegetable aliment is the starch which it contains. But of all species of starch, the finest and purest is that which is obtained from the root of *Maranta arundinacea*, better known by the name of Indian arrow-root, an appellation which it owes to its great efficacy in the cure of wounds inflicted by arrows poisoned with the juice of the Manchineel-tree, *Hippomane mancinella*. For this purpose it is formed into a cataplasm, but prepared otherwise it is a mild and nutritive aliment, very generally prescribed to invalids whose digestive organs stand in need of restoration.

STATIONS OF PLANTS.—The stations of plants are certain especial and peculiar localities which certain species are uniformly found to affect, whatever may be their general and geographical habitation or region on the surface of the globe. Of these some are aquatic, being selected by plants that will not grow unless they are either wholly or partially immersed in water. [See AQUATICS.] Others are maritime, growing only on the sea-coast, or at no great distance from it, as *Glaux*, *Statice*, *Crithmum*. Others are champaign, that is, affecting chiefly the plains, meadows, and cultivated fields, as Cardamine, Tragopogon, Agrostemma. Some are Sylvatic, as *Stachys sylvatica*, *Angelica sylvestris*. Some are Alpine,—that is, growing on the summits of lofty mountains, as *Poa alpina*, and many of the mosses and lichens; and lastly, some are vegetable, being the station of Parasites, whether true or false.

STEM.—The stem is the trunk of trees, and of the greater part of herbs. It is cylindrical and tapering, as in the Oak and Elm; or compressed, as in flat-stalked Pondweed; or quadrangular, as in Scrophularia; or jointed, as in the Pink. It is also further distinguished as being simple or compound, solid or tubular, upright or nodding, creeping, climbing, twining. Of these varieties, the last three are the most remarkable. First, the creeping stem, which, being too feeble to support itself in an upright position, extends or creeps horizontally along the surface of the earth, and sends down roots at regular intervals, to extract from the soil new supplies of aliment. It is exemplified in *Potentilla reptans*. Secondly, the climbing stem, which, being also too feeble to support itself in an upright position, attaches itself by means of lateral roots, or of other appropriate organs, to other plants, or to other bodies, for support, and thus attains to the elevation proper to the species. It is exemplified in the vine and ivy. Thirdly, the twining stem, the most elegant and most singular of them all, which, being also too feeble to support itself in an upright position, ascends not merely by clinging to a prop, but by winding spirally around it; the winding never being effected at random, but always in a specific and determinate manner, which is always the same in

the same species of plant. Thus in the hop plant, *Humulus Lupulus*, the winding proceeds in a direction from left to right, or according to the apparent motion of the sun, and never otherwise; while in *Convolvulus sepium*, or Great Bindweed, it proceeds in a direction from right to left, or contrary to the apparent motion of the sun, and never otherwise. If you attempt to compel the stem to reverse its mode of winding, you kill the plant.

STIGMA.—The stigma is the upper extremity or summit of the style, or pistil, or metamorphosed leaf, out of which the pistil or carpellum is formed. It is without a cuticle, and is hence either humid or papillose.

STINGS.—Stings are awl-shaped processes originating in the cuticle of the leaf or stem, and discharging a venomous fluid when pressed, as in the common nettle.

STIPE.—The trunk that supports the *pileus* of the fungi is denominated the stipe—*stipes*.

STIPULES.—The stipules—*stipulæ*, are small appendages attached to the base of the leaf-stalk of many plants, and resembling leaves in miniature.

STOMATA.—The small and minute openings that occur in the cuticle of the leaves of many plants, occupying the area of the meshes, and formerly known by the name of pores or apertures, are now by the general consent of botanists denominated *stomata*. They are generally of an oval figure, though not always so; and their edge has the appearance of being a sort of thickened sphincter capable of opening and shutting. They have been well described and figured by M. Ad. Brongniart, in his illustrations of the anatomy of leaves; and yet some of the German doctors, together with our countryman Dr. Robert Brown, deny that there is any opening in the case, and contend that the stomata are merely glands lurking under the cuticle. M. Decandolle holds them to be furnished with decided apertures, and organs of exhalation chiefly, but capable also of imbibing such aqueous vapours as may be found floating in the atmosphere. If it should be asked, “Who shall decide where doctors disagree?” we can only reply in the words of the Poet:—

“Non nostrum, inter vos, tantas componere lites.”

Time may throw more light on the subject, but no one, as we believe, has found stomata in the root of any plant, and but rarely in fleshy fruits or bulbs, or in the submersed parts of aquatics, or in plants destitute of tracheæ, or of flowers.

STRAW.—The straw or culm, *culmus*, is the trunk of the grasses, rushes, sedges, and of several other plants nearly allied to them. In

its figure it is generally cylindrical, as in wheat and barley; but in some few plants it is triangular, as in *Schænus* and *Cyperus*. In its structure it is hollow and jointed, as in the grasses; or solid, that is, filled with a soft and spongy pith, as in the Bulrush.

STROBILE.—The strobile is an indurated *amentum*, the carpella of which are scale-like, covering naked seeds.

STRUCTURE OF LIVING FABRICS.—The fabric of every living body is composed partly of solids and partly of fluids. The solids are the substances which constitute the several parts or organs that give form to the fabric; as the head, feet, limbs, and trunk of animals; or the root, trunk, branches, leaves, and flowers of vegetables. The fluids are substances absorbed or imbibed from without, or they are secretions or exhalations from the solids—as blood, chyle, lymph, urine—sap, nectar, cambium, expressed juices. While life remains the fluids are in motion, except in the very singular case of the hybernation of some animals, and perhaps of some plants; or in the equally singular case of some very vivacious animalcules, which, though left on the stage of the microscope till they have shrunk by the evaporation of the fluid to a mere dry and shrivelled up membrane, will again revive and move, as at first, upon the application of a little fresh water. The same thing happens to many of the mosses, which will revive and recover their verdure, when moistened with water, even after having been completely dried, and kept in a dried state for many years.

The perfection of the individual is in the ratio of the complexity of its organization. The fewer the organs, the fewer the faculties with which the individual is endowed. This is very evident even on the most superficial survey of the grand divisions of the empire of organized nature. Look at any individual, or at any group of individuals, belonging to the vegetable kingdom. Where are the organs of locomotion? where are the organs of sense? They are organs of which the vegetable is altogether destitute. Look at any individual, or at any group of individuals, belonging to the animal kingdom, and the organs of sense, and of locomotion, are the first that attract your notice. Thus the animal is elevated in the scale of existence to a rank far surpassing that of the vegetable; first, by means of the organs of sense and of intellection, by which it holds communication with the external world, and is rendered conscious of its own individuality; and, secondly, by means of the organs of locomotion, by which it transports itself even to distant regions, and ranges in pursuit of new gratifications.

But each kingdom has a gradation within itself, from the highest or most organized orders, to the lowest or least organized orders—from the *vertebrata* to the *infusoria*, on the one hand; and from the trees

of the forest, to the *Fungus* that gives colour to the polar snows, on the other.

This gradation gives rise to the division of Perfect and Imperfect plants or animals,—that is, in comparison with one another,—for no work of God is absolutely imperfect. But there are degrees of perfection which have been ordained or instituted, and perpetuated by the Creator, all conspiring to the accomplishment of one grand end, which man may not perceive, but which exists notwithstanding.

If we follow up the detail of the Structure of living Fabrics, we shall find it indispensable, or, at the least, expedient, to institute another division also, consisting of two branches; namely, that of the External Structure, and that of the Internal Structure. In animals, the first includes the head, the body, the limbs, the organs of sense;—the second, the bones, the muscles, the brain, the heart, the lungs, the intestines, of which we will give a partial sketch in our article on Zoology. In plants, the first includes the root, the stem, the branches, the leaf, the flower, the seed; the second, the cells, the vessels, the fibres, the layers, the bark, the wood, the pith; all which will be found in their lexicographical order.

STORAX.—This balsam is obtained from *Styrax officinale*, a tree which grows in France, Italy, and the islands of the Levant. It is extracted by means of incisions; and concretes into cakes or masses of an irregular form, and of a brown or reddish colour. Its taste is spicy, and its smell fragrant. In this country it is employed in perfumery; in Catholic and Mahometan countries it is consumed as incense.

STYLE.—The style is the middle portion of the pistil, issuing generally from the upper extremity of the ovary, and bearing the stigma on its summit. It is deciduous, and falls when the ovary is ripe; or permanent, and adheres to the fruit.

SUSCEPTIBILITY OF VEGETABLES.—Of the susceptibilities of living fabrics, some are common both to plants and animals, others are proper to animals only. 1st. Tissual susceptibility; that is, the physical capacity of extension and of spontaneous contraction which is found to be inherent in primary tissues, is common to both. Thus, in elevating the arm to a perpendicular position, the tissue of the arm-pit is extended to more than double its former length; and in the forcible bending of the bough of a tree there is an extension of a similar sort. 2nd. Vital susceptibility, or that capacity of living organs which enables them to receive and to obey the impulse of *stimuli*, of the impression and operation of which the individual knows nothing, is common to both also. Thus the fluids that are lodged in the soil excite the susceptibilities of the extreme fibriles or spongiolæ of the

root, being first admitted into, and then propelled and distributed throughout the fabric, while the individual knows nothing of it. Thus also the stomach of animals is excited to action by the presence of aliment, and the heart by the ingress of blood ; and thus are digestion, circulation, and nutrition maintained in the fabric without either our knowledge or our notice. But, 3rd. Cerebral susceptibility, or that capacity of living organs which enables them to receive and to obey the impulse of stimuli, and to transmit the impression made to a common centre of feeling and of consciousness, is proper to animals only. Yet it has been claimed for plants also ; and the claim has been advanced by botanists of the highest celebrity, as well as by physiological enquirers of no mean reputation. Dr. Watson, bishop of Llandaff ; Dr. Darwin, the author of the “ Loves of Plants ; ” Dr. Percival, of Manchester ; and Sir J. E. Smith, the founder and late President of the Linnæan Society of London—have each of them been advocates for the doctrine of vegetable sensation. Now a doctrine supported by writers of such eminence and distinction must surely have something in it, if not very convincing, at least very plausible. Let us see on what foundation the doctrine is made to rest.

One of the several arguments adduced in defence of the doctrine is that of the fact of the excitability of plants by the natural *stimuli* of light and heat ; and, as it is also alleged, of cold and of darkness. 1st. If a plant is vegetating in a dark chamber, it will turn itself into any hole or aperture that may be opened for the admission of light. 2nd. Leaves, if not prevented by some insurmountable and accidental cause, do uniformly turn their upper surface to the light. 3rd. The leaves of many plants assume a position in the night very different from that which they occupied in the day. This phenomenon Linnæus denominated the *sleep of plants* ; which see. 4th. The flowers of many plants open and shut only at certain hours or periods of the day. This, Linnæus denominated the *Horologium Floræ* ; which see. 5th. Many plants protrude their leaves only when the temperature of the atmosphere has reached a certain point of elevation ; some in January, some in February, and some in March. This, Linnæus denominated the *Calendarium Floræ* ; which see, as also the article EXCITABILITY.

To account for the above phenomena, Darwin claims for vegetables the faculty of sensation, and gratuitously assigns to them a *sensorium* or union of nerves residing in each bud. [Zoon. vol. i. sect. 13.] We may fairly contend, however, that the mere susceptibility of the vegetable to the stimulus of light and heat, is no proof of its being endowed with the faculty of sensation ; because even in animals, which evidently possess sensation, there are still many movements of which the individual is not conscious. Take the case of the circula-

tion of the blood, or of the processes of digestion, absorption, and nutrition, and you have a good example of the fact. Besides, the action of light and of heat would amount to something, even upon bodies destitute both of life and of feeling. Expose a piece of dyed cloth to the action of the direct rays of the sun, and you will soon begin to see its colour begin to fade. Hold a sheet of paper or of parchment before a bright fire, and it will immediately roll itself up into a scroll. Place a snow-ball in the same situation, and it will quickly dissolve into water. Try the experiment upon a piece of wet clay, and it will shrink in all its dimensions. Repeat the experiment upon a lump of wax, and it will speedily expand in volume. Hence we regard the bending of the stem towards the small aperture in the dark chamber, and the unfolding of the flower at a given temperature, as being nothing more than the chemical action of light or of heat attracting or expanding the vegetable fabric, and thus facilitating the growth and nutrition of the plant. But vegetables, says Darwin, perceive not only the impressions of *stimuli*, they perceive also negatives, and are consequently endowed with sensation. Cold and darkness are negatives [Zoon. vol. i. sect. 13.] Admitting that cold and darkness are negatives, what do we gain by it after all? If the stimulus of heat or of light is withdrawn, its effect must necessarily subside, whether its withdrawal is perceived by the body that has been stimulated or not. If the paper or parchment is withdrawn from before the fire, and placed in a cooler atmosphere, it gradually recovers its former shape without any perception of the negation of cold. So also the flower closes, and the leaves fold up, without being conscious in any degree of their own movements. If we do not concede the attribute of sensation to the phenomenon of the excitability of vegetables by the action of the natural *stimuli* of light and of heat, it has been thought that we must at least concede it to the phenomenon of their irritability by the action of accidental and extraneous or artificial *stimuli*. The shrinking of the leaflets of *Mimosa pudica* when touched; the closing of the leaves of *Dionaea Muscipula* and of several species of *Drosera* if a fly but alights on them; the sudden incurvation of the filaments of *Berberis communis* if touched on the inner side, and the hasty reflection of the style of *Stylidium fruticosum* if the stigma is but touched with the point of the finger, are the examples of vegetable irritability which are usually adduced in support of the doctrine in question. See IRRITABILITY.

But still we have no certain or decided proof that plants are endowed with the attribute of sensation. The irritability which they exhibit upon the application of accidental or artificial *stimuli* does not prove the fact. Sir J. E. Smith found that the stamens of the flower of the

Barberry retained their contractile power even when the petal with its annexed filament had fallen to the ground, and could no longer be said to be in a living state. [Introduct. p. 326.] But a faculty which plants may retain, even when dead, is surely no proof of their having been endowed with sensation when alive. Besides, they present no apparatus whatever of feeling or of perception—nothing that is analogous to the brain, nothing that is analogous to the nerves of animals. But does not the *Mimosa*, it may be said, shrink even from the touch? There is a great difference between a mere shrinking from the touch, and a shrinking from danger apprehended, as in the case of animals. The harlequin that is made of goldbeater's skin, shrinks from the touch or heat of the hand, and tumbles about as if it were actually alive; but no one, in spite of its whimsical freaks, supposes that it feels. Might not the phenomenon of the irritability of plants be accounted for from the influence of the electric or galvanic fluid, without having recourse to the faculty of sensation? If a dead frog has been made to leap by means of the agency of this power, and a dead man to shake his fist in the face of the experimenter, well might we ascribe the shrinking of the *Mimosa*, the collapsing of *Dionæa*, and the elastic spring of *Stylidium*, to a similar cause.

Further, the advocates of the doctrine of vegetable sensibility contend that they find in vegetables movements that indicate not only sensation, but also instinct. [Darwin's *Zoon.* vol. i. sect. 16.] What less than instinct, it has been said, could direct the radicle in its irresistible descent into the earth, and the plumet in its irresistible ascent into the air in the process of germination; or the twining stem in its spiral ascent around its prop, never taken at random, but always in a determinate manner; or the tendril to multiply its circumvolutions, till it has got a hold that is inseparable? The fact is indeed inexplicable on grounds merely chemical or mechanical, and yet the admission of instinct does not solve the difficulty. Neither do we think the term is rightly applied to express the growth or direction of any organ or fabric. The legitimate use of it seems rather to be confined to the expressing of the act of an individual being regarded as sentient. We might as well say that the upper growth of the teeth of the lower jaw, and the downward growth of the teeth of the upper jaw, and the twisted and spiral growth of the horns of the ram, are the result of an instinct born with, and inherent in, these organs. Thus the idea of the existence of instinct in vegetables is palpably erroneous. The phenomena for which it is alleged to account are the result of vitality, but not of feeling. We regard the term Spontaneity as being less exceptionable than that of Instinct; but still it is a spontaneity that feeling has nothing to do with.

Lastly, the advocates of the doctrine in question regard certain vegetable movements as affording indubitable indications, not only of sensation and perception, but of volition, desire, and design. [Zoon. i. 13.] 1st. If the roots of vegetables are lodged in the earth, they are found to have the power of protruding their fibres in the direction of the best soil. 2nd. If a vessel filled with water is placed within six or eight inches of the stem of a growing cucumber, the shoot will elongate in the direction of the vessel, and follow it till it reaches the water. 3rd. The movements of the leaves of *Hedysarum gyrans* are perpetual, for they cease neither by night nor by day; and hence we are called upon to believe them to be voluntary. 4th. The Water Lily does not put forth its blossom till it reaches the surface of the stream in which it grows, be it shallow or be it deep. 5th. The style of *Gloriosa superba* bends itself towards the stamens, and the stamens of *Saxifraga* bend themselves down to the stigma, in obedience, as it has been alleged, to a sort of amorous desire.

Such are the indications which are thought to demonstrate the existence of vegetable volition, desire, and design. Yet the direction of the root proves only the agency of a sort of physical or chemical attraction between its extreme fibrils and the soil; and the direction of the stem proves only the agency of a similar attraction between the young and tender shoot and the water, like the attraction of the magnet for iron, or of a rubbed cylinder of glass for a tuft of thistle down. At the best it is but a vegetable locomotion. The shoot does not walk towards the water, it only grows towards it. The phenomenon of the self-moving leaves of *Hedysarum gyrans* participates more of the character of animal spontaneity than any other movement hitherto observed in vegetables; and yet it is but a solitary fact, and cannot establish a position that must rest on a copious induction of particulars. How is it that its movements never intermit? In this they resemble rather those movements of the animal system that are wholly involuntary, for such have no intermissions; whereas the movements that proceed from volition soon begin to induce fatigue, and have frequent intermissions. If we were to grant that the water-lily grows by volition, we should be granting too much: for even man, who stands at the head of the animal creation, cannot grow by volition, and cannot add an inch to his stature. The sympathy subsisting between the stamens and pistils is very singular, and very surprising; but the amorous desire which it has been thought to indicate, and the consequent movement which it has been thought to cause, are merely the work of a glowing imagination. It was a fancy entertained by some of the earlier of the Greek philosophers, as we learn from Aristotle, Περὶ φυτῶν, and it has been sung most delightfully among moderns,

by Dr. Darwin, in his "Loves of Plants." The reader is overwhelmed with the beauties of diction, with the harmony of numbers, and with the novelty and apparent plausibility of the doctrine, and is almost persuaded to become a Darwinian; though the doctrine is any thing but a legitimate deduction from the phenomena of vegetable life. It is a very pretty poetical fiction, but a very unfounded philosophical fact. Let us regard the phenomenon as inexplicable, rather than admit a solution that is unwarranted and unwarrantable.

Some have thought that we ought to ascribe sensation to vegetables from the similarity of their structure to that of animals. What though Darwin has called certain vegetable organs veins, others nerves, and others arteries? Their functions are in no respect similar to the veins, nerves, and arteries, of the animal system. You cannot prove the existence of a real circulation; you cannot point out the propelling organ. Where is the heart, where is the stomach, where are the intestines? Where is the proof that nerves reside in the bud, and where are the muscles which they put in action? Even the analogy of leaves to lungs is very faint, but it is better founded than that of veins and arteries; and hence leaves have been regarded from time immemorial as being the veritable lungs of plants.

Finally, some physiologists, among whom we may place Sir J. E. Smith, have believed that a legitimate argument for the sensation of vegetables might be drawn from the fact of the benevolence of the Deity, regarding the endowment as having been conferred for the purpose of extending the blessing of conscious existence to an additional and incalculably numerous class of individual beings, which are rendered peculiarly interesting to man, both from their beauty and utility. But as vegetables are exposed indiscriminately to the perpetual attacks both of men and of animals, without having any effectual means whether of defence or escape, sensation could hardly be regarded as a benefit to them, if they were even endowed with it. It would rather be the means of affecting them with pain. They are cut, and cropped, and mangled, and mowed down, and still they are obliged to live and to suffer. If you say that animals suffer also, and that God is yet good,—we answer that the cases are not altogether the same. The lowest animal that exists has always some means or other of defence against, or escape from, the attacks of other animals, or of man. The animal, consequently, has a chance for the preservation of its life, which the plant has not. If you say that the strongest still prevails, or that man, who is placed at the head of the animal creation, does not scruple to slaughter such as are good for food, or to destroy such as have the means of annoying him,—we acknowledge it to be a law of nature that one species of animal shall live at the expense, or

by the destruction, of another. Man is even the destroyer of man; yet it is not often by a destruction that is piecemeal. It is not by the cutting off of one slice to-day, and another slice to-morrow, from the hip of the devoted victim, as the savage Abyssinians are said to do to their cattle,—a cruelty which the inferior animals, and even civilized man, inflict most unmercifully upon vegetables—if it be true that vegetables feel—in the many mowings of the green lawn, in the perpetual bite or browsing of the tender herbage, in the pruning and nailing of the annual shoot, and in the periodical clippings or loppings of shrubs or of trees. It is rather by a destruction that is prompt and sudden that man assails his victim, extinguishing life and causing death in an instant; and it is certain that an animal can suffer death but once, though a plant, upon this supposition, might have many deaths to suffer. As it is, we have a sort of instinctive apprehension that plants do not feel, and hence we cut and chop them up without mercy. Hence also the mower whets his scythe, and the reaper his sickle, and the woodman his axe, without experiencing any emotions whether of sympathy or of sorrow; and hence we can bear to witness or to contemplate the havoc that is annually committed in the meadow or in the corn-field, or in the wood or forest, without having our feelings outraged or our sympathies excited; though we cannot bear either to witness or to contemplate the pains and sorrows of suffering animals, but with the tear of sympathy or the cry of commiseration.

From the above premises it follows irresistibly that plants, though exhibiting indubitable indications of such tissual and organic susceptibilities as are proper to their rank in the scale of being, do not, after all, exhibit any satisfactory indications of the sensible or voluntary susceptibilities of animals, and do not, in fact, either feel, or will, or desire, or design. The movements which they display are singular, indeed, and surprising, but they are not such as evince any legitimate evidence whether of sensation or of intellection. These are attributes that reside only in animals, and that reach their highest degree only in man.

SUCCULENT THREADS.—In the centre of the barren flowers of the mosses, and accompanying the presumed stamens, there is generally to be found a number of jointed and necklace-looking substances, which Hedwig, without determining their function, denominated succulent threads.

SUCKER.—Many plants send out a horizontal root from about the collar, which ultimately protrudes a bud that emerges into the air and becomes a little stem, as in *Syringa*. The stem thus produced is a sucker.

SUGAR.—The commodity known by the name of sugar, and so

much used as an article of food, is the produce of *Saccharum officinarum*, or the Sugar Cane, a native both of the East and West Indies. It has a sweet and luscious taste, but is without smell. When pure its colour is white, and when crystallized it is somewhat transparent. It is soluble in water, and particularly in boiling water, which will dissolve a quantity of sugar equal to its own weight. It is soluble also in alcohol and the acids. According to Dr. Thomson, its specific gravity is 1.4045; and its constituent elements as follows: oxygen, 64.7; carbon, 27.5; hydrogen, 7.8.

Sugar is obtained also from the sap of the Birch-tree and American Maple; from the juice of the grape when ripe; from the root of *Beta vulgaris*, and various other plants; and from the nectary of most flowers. Its utility, whether as an aliment or condiment, is well known; and it is much relished, not only by man, but by many other animals. Bees sip it from flowers under the modification of nectar, and when they discharge it into their cells it is honey.

SUFFOCATION.—Owing to the accumulation of extraneous substances that attach themselves to the exterior of the leaf or stem, it sometimes happens that the pores of the epidermis are so much obstructed as to induce disease. This disease is termed suffocation. It may be caused by the immoderate growth of Lichens or of Fungi; or by the settlement of colonies of insects; or by the web of *Acarus tellarius*; or by the extravasation of juices which coagulate on the surface so as to form a crust, which locks up or suffocates the leaf or part affected, or renders it a fit nidus for the eggs of insects.

SUPERFETATION.—If an ovary whose stigma has been sprinkled with two distinct species of pollen produces seeds, some of which are the issue of the agency of the one species, and some of that of the other; or if an individual seed bears marks of being the joint issue of the two pollens united, the phenomenon is denominated superfetation. Of the first species of superfetation Mr. Knight furnished an example, when, by impregnating a white pea-blossom with the pollen both of a white and grey pea, white and grey seeds were obtained. But of the other species of superfetation we know of no satisfactory example.

SUTURE.—The edges by which two valves unite are called sutures. In the carpellum, the suture corresponding to the midrib is the dorsal suture; the other, corresponding to the margins, is the ventral suture.

SUTURAL.—A mode of the dehiscence of fruits. See PERICARP.

TAIL.—The tail, *cauda*, is an elongated and feather-like appendage surmounting the apex of the seed, but formed of the persistent style, as in *Clematis*.

TANNIN.—If a quantity of pounded Nut-galls, or bruised seeds of

the Grape, is taken and dissolved in cold water, and the solution evaporated to dryness, there will be left behind a brittle and yellowish substance of a highly astringent taste. This substance is tannin. It is soluble both in water and in alcohol, but insoluble in ether. With the salts of iron it strikes a black; and when a solution of gelatine is mixed with an aqueous solution of tannin, the tannin and gelatine fall down in combination and form an insoluble precipitate.

Chemists enumerate seven different species of tannin as being the most important, or the purest. 1st. Tannin obtained from the seeds of the grape. 2nd. The tannin of nut-galls. 3rd. The tannin of Catechu—*Acacia Catechu*. 4th. The tannin of Dragon's blood—*Dracæna Draco*. 5th. The tannin of Sumach—*Rhus coriaria*. 6th. The tannin obtained from the wood of *Morus tinctoria*. 7th. The tannin obtained from the common Kino of the shops, an extract from *Cocoloba urifera*.

Tannin may be obtained from a great variety of plants besides those now mentioned, but chiefly from their bark. The barks of the Oak-tree and Leicester Willow yield it in the greatest abundance; and in its application to the arts it is of the most incalculable utility to man. In consequence of its peculiar property of forming an insoluble compound with gelatine, it becomes the means by which the hides of animals are converted into leather, as well as the principle on which the important art of tanning wholly depends.

TAXONOMY.—This Greek compound is by some writers made use of to denote that department of botany in which plants are classified, or arranged in a system.

TENDRIL.—The tendril is a thread-shaped and generally spiral process issuing from the stem, branch, or petiole, and sometimes even from the expansion of the leaf itself; being an organ by which plants of weak and climbing stems attach themselves to other plants, or to other substances, for support, and being always much stronger than a branch of the same size. In attaching itself to its supporter, it generally twists itself round till it has taken so many circumvolutions as to make its hold secure. But what is very singular is, that there are some plants—as *Bryonia*—whose tendrils, after performing a certain number of circumvolutions in one direction, twist themselves about spontaneously, and perform their future circumvolutions in a contrary direction. But all tendrils do not twist round their supporter. Those of *Vitis hederacea*, the Virginian Creeper, terminate ultimately in a flat and fleshy process, by which they can attach themselves, in default of better support, even to the surface of a brick or stone wall.

TEPALS.—The parts or divisions of a perianth, strictly so called, are

tepals. Thus the perianth of the Tulip is six-tepalled, first green, and then coming coloured.

TERCINE.—The third coating of the *ovulum*, or the film proper that sometimes invests the corion, is by Mirbel denominated the *Tercine*.

TESTA.—This term was employed by Gærtner to denote the outer coat of the seed. It is equivalent to the primine of Mirbel.

THALAMUS.—The receptacle of the flower is sometimes denominated the *thalamus*, or *torus*, or *clinium*.

THALLUS.—The frond of Cryptogamous plants that bears the fructification, whether by seeds or sporules, is denominated the *thallus*.

THECA.—The theca is the urn or capsule that contains the seeds or sporules of the mosses.

THORN.—The thorn is a species of armature originating in the wood, being an abortive and indurated bud, and exemplified in the genus *Mimosa*, or *Cratægus*; the former presenting in some of its species a host of spears that is impenetrable even to the rhinoceros; and the latter a barrier sufficiently formidable to prevent the incursions of cattle, as in our Quicksets.

THYRSE.—The thyse—*thyrsus*, is a species of inflorescence, being an assemblage of flowers supported upon a primary peduncle, subdivided as in the branching panicle; but differing from it in having the lower or partial peduncles longer, and placed in a horizontal or expanding direction; and the upper ones shorter and more erect. It is exemplified in *Syringa vulgaris*, and in the vine.

TRUNK.—The trunk, or *caudex ascendens* of Linnæus, is that part of the plant which springs immediately from the root, and ascends in a vertical position above the surface of the soil, supporting the branches, and constituting for the most part the principal bulk of the individual. It is a term taken from the Latin *truncus*, and has the same signification among botanists which it had among the ancient classics.

“Olim truncus eram ficulnus.”—HOR. LIB. I. Sat. viii.

In their size, trunks are to be found of all dimensions, from that of the diminutive *Draba* that surmounts the parched wall, to that of the lofty mountain palm, that rears its head to the clouds. This immense and gigantic tree, the *Palma altissima* of Sloane, and the *Areca oleracea* of modern botanists, is a native of the West Indies, growing to the height of 120 feet, sometimes to the height of 150 feet, and even, as it is said, to the very extraordinary height of 200 feet, being about seven feet in circumference at the base, but gra-

dually tapering towards the summit, and thus forming with its lofty crown of fronds the noblest object of vegetable creation,

“ Where casts the mountain palm on high
Its lengthened shadow from the evening sky.”

MONTGOMERY'S WEST INDIES.

But the great girth of the trunk of some trees is quite as astonishing as the great height of the trunk of others. Adanson, when at Senegal, saw a Baobab—*Adansonia digitata*—that measured seventy feet in height from the root to the top of the vertical branches, with a diameter of 160 feet at the level of the horizontal branches, each as large as a tall tree; the trunk being only about twelve or fifteen feet in height, but with a diameter of the enormous width of not less than twenty-seven feet. This immense trunk is sometimes hollowed out and converted into a sort of house or cabin, serving for the abode of several families of negroes. [Fam. des Plant. 212.]

Nor is this all. From the leaves the natives obtain a very pleasant seasoning for their food; from the root, a purgative; from the bark, a pectoral anodyne; from the parenchyma of the trunk, a cataplasm that cures cutaneous eruptions; from the fruit they compose an agreeably astringent draught; they eat the kernel; they smoke the calyx; and they use the capsule as a spoon. [Naufrage de la Freg. la Mèduse, 1816.]

As applicable to the higher orders of plants, trunks are distinguished into the three following species—the stem, the culm, the stipe; an account of which will be found in their proper places.

TUBE.—The lower part of a monopetalous corolla, being generally of a cylindrical form, is by botanists denominated the tube.

TUBEROUS ROOT.—Some roots are tuberous—that is, giving origin to a tuber or tubercle, or, as botanists now call it, a subterranean stem, or to several such stems united in a cluster. If the tuber is single, it is generally solid, as in *Bunium Bulbocastanum*. If the tubers are not single, they are often in pairs, as in *Orchis Masculula* or Early Orchis. If the knobs of this species are taken and separated, and then immersed in water, the one will be found to sink and the other to swim. This is a phenomenon that seems to have puzzled the simplists of antiquity not a little, and to have given rise to a great deal of idle and superstitious conjecture. It was believed that the knob that swims must necessarily have possessed some peculiar and potent properties; and accordingly some potent properties were very liberally ascribed to it, of which the reader will find a full and particular account in Gerard's great work, who seems to have believed all that he relates, and treats the subject as if he loved it. [Historie of Plants, 207.] One thing

he has omitted. If prepared in a particular manner, and secretly attached to, or concealed in, the dress of any one, it was believed to have the singular property of exciting, by due management, a violent attachment in the breast of the wearer to the person who had thus concealed it. This belief is still a vulgar error among the ignorant and superstitious, though the sinking of the one knob and the swimming of the other have been accounted for from the regular operation of natural causes, and the mystery and magic charm of the phenomenon altogether dissolved. The swimming knob is the knob that nourished the plant of the present year, now light and exhausted; the sinking knob is the knob that is to nourish the plant of next year, still heavy and full of nutriment.

TUFT.—The tuft is a hair-like or plume-like substance, forming the appendage of some seeds, as that of *Epilobium* and *Asclepias*.

TUMOURS.—Tumours are irregular enlargements of the organs of the vegetable, disfiguring, but not always injuring, the plant. See **BUNCHES**.

TURNIP FLY.—The insect that attacks the seed leaves of the turnip, and often destroys a whole field in a night or two, has generally been regarded by Entymologists as the caterpillar of a little black jumping beetle which they call *Haltica nemorum*; and in this they were, no doubt, to a certain extent right; although they do not seem to have known where, or in what state, it wintered. But Mr. Yarrell now attributes much of the damage which the crop sustains, to the caterpillar of a species of insect belonging to the family of the *Tenthredinidæ* or Saw-flies; namely, that of *Athalia Centifoliæ*, which, after feeding to the full on the *parenchyma* of the tender leaf, buries itself in the soil, and by an exudation which transpires through the skin, forms a cocoon, in which it winters, and undergoes its future metamorphoses; coming out a perfect fly, about the time turnips are in season for it; and again laying its eggs in the leaf, which are again soon metamorphosed into caterpillars. Thus we have a rational and satisfactory account of the whole process, whether as it regards the insect or the plant, and from Mr. Yarrell's high character as a zoologist, we have reason to believe that all is correct. [Zoolog. Journ., vol. ii. part 1.]

TWINING STEM.—The twining stem is a stem that ascends its prop spirally and uniformly, in a direction either from right to left, or the contrary, and never otherwise. See the article **STEM**.

UMBEL.—The umbel is a mode of flowering, in which a number of flower-stalks issuing from a common centre diverge like the rays of an umbrella, bearing their flowers on the summit, and raising them to about the same height. The carrot, parsnip, and common hemlock

are familiar examples. If the rays of the umbel are undivided, so that an individual ray supports but a single flower, as in *Hydrocotyle*, the umbel is said to be simple. But if the rays of the primary umbel are themselves subdivided so as to form and support secondary umbels, as in *Heracleum*, and most umbellate plants, the umbel is then said to be compound. It is terminal, as in the Carrot; or lateral, as in *Caucalis nodiflora*.

UMBILICUS.—The umbilicus is merely another term for the hilum or scar, which is occasioned by the fracture of the umbilical cord.

UMBILICAL CORD.—The thread-like process by which some seeds are attached to the placenta, is the umbilical cord, already described at the article FUNICULUS.

UNDERSHRUB.—Undershrubs are plants perishing either wholly or in part; but sometimes surviving by their woody parts for more than one year, as Tree Mignonette.

UNGUIS.—The *unguis* is merely the Latin term for that part of a petal which we have already defined under the head of the article CLAW.

UPAS POISON.—The Upas of Java was long supposed to be a single tree, situated in the interior of the island, and exhaling a most malignant and pestilential vapour that cut up all vegetation for many miles around it, and was certain death to the man or animal that had the hardihood or misfortune to approach it. This account though gravely or fraudulently related by Foëresch, as if a positive fact, is now shown to be a palpable fiction, as may be seen by consulting Dr. Horsfield's account of the Upas-tree, as introduced into the eighth volume of the "Batavian Transactions," by Sir Stamford Raffles, or as excerpted in Hooker's "Companion to the Botanical Magazine." The tree in question is the *Antiaris* or antschar of the natives, and the *Antiaris toxicaria* of botanists. Many plants of the species grow in the island, and in the most fertile spots; and twining plants grow round the stem. But the gum or milky juice that exudes from the bark or wood, when cut into, is a deadly poison, and is used by the natives to poison arrows. To this poison they give the name of Upas. Thus, Upas is not the name of the tree, but of the poison which it produces. The tree may be approached without injury; and a criminal, if sent to procure a portion of the poison, as the condition of obtaining a pardon, would have no difficulty in filling his box.

The Upas poison has been also mistaken for the Upas valley—the valley of poison, or the valley of death—*Guevo Upas*. But this is now found to be a valley on the top of a mountain, the approach to which is dangerous, and the descent to the bottom, death. It seemed to a correspondent of Mr. Loudon's, who visited it in 1830, to be

about half a mile in circumference, with a bottom quite flat, at the depth of thirty feet. A dog let down died in seven minutes, a fowl in a minute and a half. Skeletons of men and of other animals were seen lying at the bottom. The deadly poison that lurks beneath is doubtless carbonic acid gas, as it is in the *Grotto del Cane* of Naples. The chain of mountains in which the Upas valley lies is volcanic; and the valley is, perhaps, an extinguished crater. [Burnett's Outlines, 551.]

UTRICLE.—The utricle is a small and bladder-like capsule, consisting of one cell and one seed. Gærtner exemplifies it in *Chenopodium* and *Clematis*, in which Sir J. E. Smith seems to regard it as being merely a cuticle.

VALVES.—The several distinct pieces into which the pericarp spontaneously separates, when the fruit is ripe, are denominated valves. All pericarps do not open in the same manner, but all individuals of the same species open in the same manner; and the persistent axis from which they separate is called the *columella*. The external surface of the valves is generally convex, and marked with a longitudinal furrow. The interior surface is generally concave. The margin is simple or inflected, forming often a prominent seam which connects the valves. The dehiscence of the valves is generally longitudinal; but there are cases in which it is transverse, as in *Anagallis*. See **PERICARP**.

VASCULAR ORGANS.—In the analysis of the vegetable fabric, the organs of which the plant are composed are found to be reducible either to epidermoid *laminæ*, or to cells, or to longitudinal fibres. The two former we have already described under the heads of the Epidermis and the Cellular Tissue. We now proceed to the latter. Are the fibres of plants tubular?

If the stem of a plant of Marigold is divided by means of a transverse section, the divided extremities of the longitudinal fibres, arranged in a circular row, immediately within the bark, will be distinctly seen, and their tubular structure demonstrated, by means of the orifices which they present, particularly when the stem has begun to wither. The tubular structure of woody plants is not so easily demonstrated. We might infer it, however, from the force and facility with which the sap ascends to the very summit of the stem in the spring and summer, and there are some cases in which we may discern it, even with the naked eye. On the horizontal section of a piece of wood that has been long exposed to the action of the atmosphere, the orifices of the longitudinal tubes will appear arranged in circular rows, in the direction of the concentric layers. Further, Hedwig affirms that he observed them

on the transverse section of a branch of the Pear-tree, detached even in the spring, when the sap was flowing. [De Fib. Veg. Ort. sect. 1.] Hence we believe that the longitudinal fibres of plants are, in fact, longitudinal tubes, containing or conveying the alimentary juices. They exhibit a considerable variety of structure, and have been distributed by botanists into several distinct species.

We will take them in the order, and under the anatomical designations, introduced or adopted by M. Mirbel, as being one of the most distinguished of modern phytologists. We are aware, indeed, that his anatomy of the sap-vessels has been denounced as fantastical, and his theory of their origin and functions as absurd; and the theory of Kiesser extolled and applauded to the skies, as being of the most philosophical character. [Sup. to Encyc. Brit. 289.] Yet we confess that we cannot see the ground whether of this censure or of this applause. Whatever may be the value or fate of M. Mirbel's theory on this subject, his anatomy was a signal step in advance of all that had preceded it; and if succeeding anatomists have surpassed him in accuracy of research, they have been indebted to his discoveries or to his errors for the progress they made. For the rest, what do we find in the greater part of Kiesser's sap-vessels, but the vessels of Mirbel, under a different name? What are we to say of his intercellular canals, as being the only medium of the sap's ascent? and what are we to think of him as an inventor of theories, when we are told that his account of the origin of the cellular tissue surpasses in absurdity even that of M. Mirbel? We have now a more formidable opponent to the theory and anatomy of Mirbel than ever Kiesser was. It is to the *eclaircissements* of M. Dutrochet that we are indebted for any new light that has been thrown on the structure of the sap-vessels. Still we cannot do without Mirbel. We must have him if it were but for the sake of refuting him, as the defenders of our faith must have the books of the infidels.

The vessels of plants are divided by Mirbel into sap-vessels and proper vessels. Of sap-vessels, he enumerates five species,—porous, tubes, spiral tubes, false spiral tubes, mixed tubes, and cellular tubes, —*les vaisseaux en chapelet*. Of proper vessels, he has but one species, which he calls simple tubes.

1st. The first species of tubes containing sap are the porous tubes. They are described by Mirbel as having comparatively a considerable width of diameter, and as being pierced with minute holes or pores, distributed in parallel rows. They abound in woody plants. They are not continuous from the base to the summit, but they unite, separate, and unite again, and finally disappear by changing into cellular tissue. The doctrine of porous tubes was attacked by the German phytologists

with as much hostility as was that of porous cells; but it met also with some strenuous defenders, and even the anti-porists were themselves obliged to admit that the vessels in question are studded with luminous points, or with little transparent vessicles, arranged as the pores are said to be; so that, at all events, Mirbel's account is not a fiction, but the mistaking of the character of certain given appearances. Thus, the matter might have been said to be left in doubt; but as Dutrochet has searched for the pores of the tubes, as he searched for the pores of the cells, without being able to find them, and has, at the same time, adduced strong reasons for supposing them to be merely small and minute molecules, imbedded in the substance of the membrane that forms the vessels [Recher. Anat. 27], we regard the doctrine of porous tubes as being no longer tenable.

2nd. The second species of tubes conducting sap is the spiral tubes—a name not imposed, but adopted by Mirbel, as being long in use. Mirbel regards them as being sap-vessels; but Dutrochet regards them as being conductors, not of sap, but of a diaphanous and peculiar fluid, the product of insolation. The reader will find the details that relate to their structure and function under the head of the article SPIRAL VESSELS.

3rd. The third species of tubes conducting sap is the false spiral tubes. According to M. Mirbel, they derive their spiral appearance merely from being cut transversely by parallel fissures. They cannot, like the true spirals, be uncoiled, and are hence fitly denominated false spirals. They are said to abound in the Lycopodia, and in Ferns, and in the soft parts of the Vine. But what says Dutrochet? He says that what Mirbel took to be parallel fissures are merely globules, arranged as in the porous tubes; that the spires may be uncoiled by means of the long-continued action of nitric acid destroying the bond of agglutination; and that the vessels in question are, after all, veritable spirals.

4th. The fourth species of tubes conducting sap is the mixed tubes; that is, tubes combining in a single individual two or more of the foregoing species. Mirbel exemplifies them in the case of the flowering Rush; but Dutrochet says there are no such vessels as mixed tubes in any plant whatever, unless you choose to regard as such, tubes having some globules arranged in transverse rows, and some scattered. Yet these accidental varieties are not to be made the ground of instituting species.

5th. The fifth species of tubes conducting sap, is that of the cellular tubes; that is, tubes composed of a succession of elongated cells, united like those of the cellular tissue. Individually they may be compared to the stem of the grasses, which is formed of several inter-

nodia separated by transverse diaphragms; and collectively to an assemblage of parallel and tangent reeds. Dutrochet admits the existence of such vessels, but he designates them by a different name, and finds them assuming not merely a longitudinal, but also a transverse direction, making part of the medullary rays. Like the cells out of which they are formed, their surface is furnished with globules.

Lastly, the only species of proper vessels that M. Mirbel describes is the simple tubes. They are the largest of all vegetable tubes, and are formed of a thin and entire membrane, without any perceptible fissure, or disruption of continuity. They abound chiefly in the bark, but are found also in the *alburnum*, and even in the matured wood. They convey the descending and elaborated juices. Dutrochet has vessels for this purpose also, but he does not give them the same name nor structure; and he has proper vessels likewise, but he does not assign to them the same function. Hence there is nothing in M. Mirbel's account of the vessels of plants that M. Dutrochet has not got something to object to.

But as M. Dutrochet may be thus said to have demolished the superstructure of M. Mirbel, it was but fair that he should substitute something in its place. This he has accordingly done, upon the firm and legitimate basis both of observation and experiment; so that instead of the vessels of Mirbel, which seem to have been multiplied into too many species, we have now the following as exhibited by Dutrochet:—1st. Globule-bearing tubes, or lymphatics—*les vaisseaux corpusculifères*. They abound in the wood, and particularly between the concentric layers of different years. They are studded with small globules or molecules that are imbedded in their walls, and they conduct the ascending sap. The ascending sap of the bleeding vine issues from the orifice that is caused by their section. 2nd. Spindle-shaped tubes or *clôstres*, so named from their spindle-like form. They consist of a longitudinal succession of short tubes, swollen in the middle, and pointed at the extremities, and often divided by transverse diaphragms. At the middle they touch, but between the points they leave spaces for the insertion of others. The membrane composing them is very firm, but it is destitute of globules. They conduct the cambium or descending and elaborated juice partly through the channel of the *alburnum*, and partly through that of the bark, till they reach the extremity of the root. 3rd. Spiral tubes, or *Tracheæ*. These Dutrochet describes as approaching pretty nearly in their structure to the true spirals of Mirbel, except that they are furnished with nervous globules like those of the cells, and terminate in a conical and spiral point, and have not the opaque edgings of which Mirbel speaks. Their function he regards as being that of conveying to the

interior of the plant a vivifying fluid, the product of insolation. 4th. Proper vessels—*les vaisseaux propres*. They are found both in herbaceous and woody plants. They have a great comparative width of diameter. They convey the descending and secreted fluids, such as the milky juice of the Fig and Spurge, and the yellow juice of the Celandine, and differ from the lymphatics chiefly in being destitute of globules. 5th. Articulated cellular tubes. They consist of a series of united cells assuming a tubular form, sometimes in a longitudinal direction, and sometimes in a transverse direction, forming the divergent layers. They are regarded by Dutrochet as an emanation from the pith. They seem to correspond to the cellular tubes of Mirbel; but in place of being furnished with pores, we are to regard them as being furnished with globules.

Such is Dutrochet's view or account of the vascular organs of plants. It seems to have been the result of much and laborious investigation. The structure of the several species is well described, and their respective functions well distinguished; and we know of nothing that ought to prevent the phytologist from adopting his account as correct, or his hypothesis of function as probable.

In addition to the above varieties of vessels, or in lieu of some one or other of them, we have now to introduce to the reader's notice the "*vital vessels*" of M. Schultz. They are found, as it is said, a little way beneath the surface of the bark, and in all parts of the plant from the roots to the leaves, forming a sort of network, by means of anastomosing branches, and conveying a fluid secreted from the crude sap which M. Schultz designates by the name of the *latex* or "vital fluid." [Lardner's Cab. Cyclop. vol. lxxv.] This discovery, together with the doctrine founded upon it, is as yet but recent, if it is not rather an old doctrine revived, and requires to be further investigated. See LATEX.

VAULT.—The vault is a process issuing from the upper extremity of the tube of a monopetalous corolla. Linnæus regarded it as a nectary. See NECTARY.

VEIL.—The veil or curtain is a fine and delicate membrane that unites the circumference of the *pileus* to the circumference of the stem of the Fungi, and protects the gills.

VEINS.—The ramifications of the petiole, as dispersed throughout the expansion of the leaf are very generally called veins; and under certain modifications they are also called nerves.

VESICULÆ.—The little air bags or bladders that serve to float the leaves of the Fuci and various other plants, are designated by the appellation of *vesiculæ*.

VERNATION.—The leafing of plants is, in the language of Linnæus, their vernation or Foliation. See the article BUD.

VICTORIA REGINA.—As the ancients had their seven wonders of the world to boast of, the most wonderful of which was perhaps the *Colossus of Rhodes*; so modern botanists have the wonders of the *Vegetable World* to boast of, the most wonderful of which is, as I presume, *Rafflesia Arnoldi*. Yet a plant has been lately discovered, in British Guiana, by a M. Schomburgk, a German botanist, which he regards as a species of a new *genus*, and which, if it were, indeed, so, would, doubtless, confer upon him a botanical immortality, as the plant in question is really and truly a vegetable wonder.—We copy the account of it from “The Saturday Magazine,” for October 14th, 1837.

“At a meeting of the Botanical Society of London, held on the 7th of September last, the following communication was read from Mr. R. H. Schomburgk, a Corresponding Member of the Royal Geographical Society of London, dated New Amsterdam, Berbice, May 11th, 1837, on a new genus allied to the Water Lily, named ‘*Victoria Regina*,’ by permission of Her Majesty. This paper was accompanied by magnificent drawings of the plant, one-half the natural size.

“It was on the 1st of January this year, while contending with the difficulties nature opposed in different forms to our progress up the river Berbice (in British Guiana), that we arrived at a point where the river expanded and formed a currentless basin. Some object on the southern extremity of this basin attracted my attention; it was impossible to form any idea what it could be, and, animating the crew to increase the rate of paddling, shortly afterwards we were opposite the object which had raised my curiosity—a vegetable wonder. All calamities were forgotten; I felt as a botanist, and felt myself rewarded.

“‘A gigantic leaf, from five to six feet in diameter, salver-shaped, with a broad rim of a light green above, and a vivid crimson below, resting upon the water. Quite in character with the wonderful leaf was the luxuriant flower, consisting of many hundred petals passing in alternate tints from pure white to rose and pink. The smooth water was covered with them, and I rowed from one to another, and observed always something new to admire. The leaf on its surface is of a bright green, in form almost orbiculate, with this exception opposite its axis, where it is slightly bent in: its diameter measured from five to six feet. Around the margin extended a rim about three to five inches high; on the inside light green, like the surface of the leaf; on the outside, like the leaf’s lower part, of a bright crimson. The stem of the flower is an inch thick near the calyx, and is studded with sharp elastic prickles, about three-quarters of an inch in length. The calyx is four-leaved, each upwards of seven inches in length and three in

breadth at the base ; they are thick, white inside, reddish brown and prickly outside. The diameter of the calyx is twelve to thirteen inches ; on it rests the magnificent flower, which, when fully enveloped, covers completely the calyx with its hundred petals. When it first opens it is white, with pink in the middle, which spreads over the whole flower the more it advances in age, and it is generally found the next day of a pink colour. As if to enhance its beauty, it is sweet-scented. Like others of its tribe, it possesses a fleshy disk, and petals and stamens pass gradually into each other, and many petaloid leaves may be observed which have vestiges of an anther."

But the discovery of this plant is not quite so much of a novelty as M. Schomburgk seems to imagine. It was discovered, and described, and figured, long ago, by M. Pöppig, a German botanist also, and named *Euryale amazonica* ; as may be seen by any one who will be at the trouble of looking into his Book of Travels in South America ; so that it cannot, with any sort of propriety, be named *Victoria Regina* ; nor presented to Her Majesty as a new *genus*.

VITALITY OF VEGETABLES.—Physiologists have been always much puzzled to give a good definition of life. They have generally regarded it as consisting in the operation of a distinct agent not necessarily connected with organized structures, whether animal or vegetable, but superadded to them by the Creator,—namely, the *vis vitæ*, or *vis formatrix* of the earlier physiologists,—the vital principle of the moderns,—and the $\psi\upsilon\chi\eta$ of the Greeks, of which so much has been said and so little understood. There is a plausibility in the supposition that has given it much currency, and a facility in accounting for all living phenomena by means of it that spares us much trouble. This idol of the imagination has been very liberally endowed with all necessary powers ;—chiefly it has been endowed with the power of resisting and of controlling or directing, to the accomplishment of its purposes, all chemical agencies. Now though its control in this respect might be granted to a great extent, yet there are certain chemical agencies which it can neither direct nor control. Where is the proof of its resisting or of its controlling the chemical agencies of those subtle substances which we denominate poisons, such as the concentrated Prussic acid, the extract of *Nux vomica*, or the juice of *Antiaris toxicaria*—the dreaded and deadly Upas, which if you by any means introduce into the animal circulation, even in the smallest portions, life is instantly annihilated?

But if it could control even these destructive agencies, it would not well account for all living phenomena, even in the estimation of its most strenuous supporters ; for it is presumed to be merely a material and mortal principle, fulfilling no high destiny, but terminating

with the termination of vital action. It might thus account for such living phenomena as occur in vegetables, or in the lower orders of animals. But what are we to do when we come to man, who is endowed with the attribute of mind, which it is not pretended that the *vis vitæ* is capable of conferring? For if it were, then all animals ought to possess it in the same proportion as man, and ought to be regarded as belonging to the same grade in the scale of being. How then is the difficulty got over? By the superaddition of another distinct substance—a *divinæ particula auræ*, an intelligent soul—the *animus* of the Latins, *νοῦς* of the Greeks. But physiologists know nothing more of such a principle than they know of a *vis vitæ*. It is not cognizable by human apprehension; it is not a legitimate deduction from any natural phenomena, though it is almost always represented as such. It is not, in short, a doctrine of physiology, but it is decidedly and unequivocally a dictate of revelation, as is evident from the Mosaic account of the creation of man. “And the Lord God formed man out of the dust of the ground, and breathed into his nostrils the breath of life; and man became a living soul.” Metaphysicians have thought it necessary to regard this superadded principle as being an immaterial substance, lest the soul of man should prove to be mortal. But whether this grave apprehension is well founded or not, or whether materiality necessarily involves mortality, we will not now stop to enquire; but will proceed to offer a definition of life, that shall be conformable to physiological observation.

As we have no idea of life independent of the body, and no experience of living phenomena independent of bodies that are organized, I would define the term as follows:—Life is that energy or attribute of organized fabrics which renders them capable of receiving and of obeying the impulse of stimuli. In animals it displays itself in the several processes of nutrition, growth, and developement of parts; in the process of reproduction of the species, and in the phenomena of the circulation of the blood, of locomotion, and of intellect. In vegetables it displays itself in the processes of nutrition, growth, and developement of parts, and in the process of the reproduction of species. Thus, life is not organization, but an attribute of organized structures, enabling them to discharge functions. Yet the life of the individual may be lost, though its organized structure may remain; as the colour of a crystal may be lost, though its crystallized form may remain. The loss of life we denominate death, which is an extinction of all living function, and of all capability of living function.

Whatever may be the defects of the above definition as applied to animals, still it may have its value as applied to vegetables. For if there should be a difficulty in explaining the phenomena of human

intellect without the aid of an immaterial principle, or in explaining some other phenomena of animal life without the aid of a *vis vitæ*, there exists no such difficulty in explaining the phenomena of vegetation. Here we have nothing mental, nothing intellectual, nothing perceptive to characterize; no locomotion to account for; no circulation to demonstrate. Thus the vegetable occupies a rank in the scale of being lower than that of the animal, and exhibits the exercise of fewer functional powers. Its inferiority seems to consist chiefly in the want of a circulating system; in the want of locomotion, or of the muscular mechanism necessary to it; and in the want of mental function, and the apparatus of a brain and nerves. In other respects, the analogy between them is sufficiently close. For, first, they are both composed partly of fluids, and partly of solids which have originated in the fluids. The principal fluids of the animal body are chyme, chyle, lymph, blood, with the generative fluid. The principal fluids of the vegetable body are sap, cambium, proper juice, with the generative fluid. The textures of the solids of both are reducible to fibre or to membrane, apparently composed of small and minute molecules; and the fibres, membranes, and fluids of both are reducible to nearly the same primary principles; the former yielding chiefly oxygen, azote, hydrogen, carbon; and the latter, carbon, oxygen, and hydrogen, with a small portion of azote in certain tribes. Secondly, they are both susceptible to the action of stimuli, and both capable of organic or vital function, whereby they absorb or take up nutriment, which they have the power of assimilating to their own substance, to complete the developement of their parts, and to furnish a perpetual supply for the repair of the perpetual waste of the several organs.

This is the double movement of Physiologists, without which it is well known that animal life cannot long subsist; as the material molecules that are being continually added to the living fabric retain their fitness for normal function only for a limited time, when they are ultimately carried off by the lymphatics, and replaced by new molecules deposited by the arterial blood. The two movements go on incessantly; the one composes, the other decomposes; the one absorbs, the other rejects; the one assimilates what is necessary to the nutrition of the fabric, the other expels what is no longer wanted in the living economy. Absorption, distribution, assimilation, belong to the first; secretion, transpiration, exhalation, belong to the second. Thus the elements of the individual fabric are continually changing, while the organization continues the same. Now though this double movement is not so evident in the plant as in the animal, yet its existence is proved by many facts; not, indeed, in the indurated part of aged trees, which can scarcely be said to be alive, but only in those

parts in which vegetable life is active. See the several following topics :—GERMINATION, FOOD, NUTRITION, DEVELOPEMENT OF PARTS, SEXUALITY, IMPREGNATION, PROPAGATION, DECAY AND DEATH OF THE PLANT.

VITELLUS.—The vitellus is a peculiar organ proper to the seeds of certain orders of plants. In the Grasses it occurs in the form of a small scale interposed between the albumen and embryo, but it takes no developement in germination. See DISSECTION OF THE SEED.

VOLVA.—The volva, or wrapper, is a sort of radical and membranous integument peculiar to certain species of Agarics, which envelops them entirely in the early stage of their growth, and then bursts open and unfolds the plant.

WATER.—Water was long regarded even by philosophers as being a primary and simple substance,—that is, as being one of the four constituent elements of which the whole of the material world was presumed to be composed,—namely, fire, air, earth, and water. It is now known to be a compound substance, the ingredients being oxygen, 85 parts in the 100, and hydrogen, 15 parts by weight nearly. This fact is proved by chemical experiment, both in the analytical and synthetical way. Water contains a portion of air, and is contained in the air of the atmosphere even during the driest weather. It dissolves a great variety of solid bodies, and is, hence, not merely nutrimental in itself, but the means of conveying to the interior of the plant such nutritious ingredients as are soluble in it. See FOOD OF PLANTS.

WARTS.—Warts are small and roundish tubercles that occur on various parts of the plant; as on the leaves of the Aloe, where they are comparatively large; on the stem of *Euonymus verucosus*; on the petiole of Passiflora; on the calyx of some species of *Campanula*; and at the serratures of the leaves, where they are regarded by Röper as being abortive *ovula*. [Lindley.]

WAX.—On the upper surface of the leaves of many trees there may often be observed a sort of varnish, which, when separated by certain chemical processes, is found to possess all the properties of bees'-wax, and is hence to be regarded as a vegetable wax. It exudes from several other parts of the plant besides the leaf, and assumes a more waxy and concrete form, as in the catkins of the poplar, alder, and fir; in the fruit of *Croton sebiferum*; but particularly in the antheræ of the flowers, from which it was at one time thought that bees extract it unaltered. Yet it seems to be the opinion of Huber [Lin. Trans. vol. iv.] that the wax is elaborated out of the fluid which the bee extracts from the nectaries of plants, and not from the pollen. It is found

also in the interior of many seeds, from which it is extracted by means of pounding them, and boiling them in water. The wax is melted, and swims on the top.

Wax, when pure, is of a whitish colour, but without taste and smell. Bees'-wax is yellow, but it may be bleached. It is insoluble in water and in alcohol. It combines with the fixed oils, and forms with them a compound called *cerate*. It combines also with the fixed alkalies, and forms with them a sort of soap. The acids have but little action on it: hence its utility as a lute. Its specific gravity is 0.9600 [Thomson]; and its elements 81.784 carbon, 12.672 hydrogen, 5.544 oxygen. [Gay-Lussac and Thenard.]

Wax possesses all the essential properties of a fixed oil, and may be regarded as a fixed oil rendered concrete by the absorption of oxygen in the process of vegetation. Hence it may be expected to occur in a great variety of states, according to its degree of oxygenation. The following species are the most distinguished; which take in common parlance the name of butter. 1st. Butter of Cacao, which is extracted from the seeds of *Theobroma Cacao*, either by boiling them in water, or by subjecting them to the action of a press. They yield almost half their bulk of wax or butter, and it is to this principle that chocolate owes its flavour and unctuousity. 2nd. Butter of Coco, which is found in the fruit of *Cocos nucifera*. It is expressed from the pulp of the nut, from which it is said to separate when in a fluid state, as cream separates from milk. 3rd. Butter of Nutmeg, which is obtained from the seeds of *Myristica officinalis*, by pounding and subjecting them to the action of a press. It is firm, orange-coloured, and of a sweet and aromatic smell. 4th. Tallow of Croton, which is obtained from the fruit of *Croton sebiferum*, by means of boiling it in water. 5th. Wax of Myrtle, which is obtained from the berries of *Myrica cerifera*. Boil the ripe berries in water, and the wax, which is thus melted, will swim on the surface.

Wax is extracted from a variety of other vegetables also, and has been detected by Proust in the green *fecula* of many plants. Certainly it is one of the most abundant of vegetable principles, and is of great utility both in medicine and the arts. It is employed as an ingredient in ointments and plasters, and in a great variety of pharmaceutical preparations. It is employed also by the sculptor, statuary, and modeller, in the exercise of their respective arts. But its chief utility consists in its being better adapted than all other substances for the manufacture of candles. The candle burns with a clear and brilliant flame, and the wick needs no snuffing.

WHORL.—The whorl is a mode of flowering in which the flowers are placed around the stem or branch as a common axis, in the form of

a ring. The verticillate flowers of Tournefort, or Labiate flowers of Linnæus, afford the best examples. The whorl is said to be sessile or pedicled, according as the individual flowers composing it are sessile or pedicled. In some plants the whorls stand close to one another, in others they stand wide apart; in some they are naked,—that is, without leaves; in others they are interspersed with small leaves or bractes, as in *Ajuga reptans*.

WING.—The two side petals of a papilionaceous flower are denominated the wings; and the membranaceous appendage that issues from the side or apex of some seeds, as that of *Syringa*, is also denominated the wing.

WINGED LEAF.—The winged leaf is a species of compound leaf, having leaflets or distinct expansions arranged on opposite sides of the petiole, as in the pea and vetch. If the insertions of the leaflets are opposite, the leaf is said to be oppositely winged; and if they are alternate, the leaf is said to be alternately winged. If the petiole supports an odd leaflet at the extremity, the leaf is said to be unequally winged; if it does not support an odd leaflet, then the leaf is said to be abruptly winged.

WOOD.—In trees or shrubs the body of the caudex, whether ascending or descending, consists chiefly of a firm and compact substance, called wood; the central portion or pith, and the external portion or bark, being but small in comparison. The horizontal section of an Oak-tree or of an Ash will demonstrate this distinctly. The account of the component parts of the wood is given under the head of the CONCENTRIC AND DIVERGENT LAYERS, and its chemical analysis under that of LIGNIN.

WOUNDS.—A wound is a forcible separation of the solid parts of the plants, effected by means of some external cause. It may be intentional, as in the case of incision, boring, girdling, grafting, pruning, felling, and such like operations; or it may be accidental, as in the case of injuries sustained by the rubbing or browsing of cattle; by the bite and depredations of insects, hares, rabbits; by lightning; by weight of fruit; or by violent storms of wind, hail, snow;—all of which accidents or operations will be found to have been introduced in their proper places.

ZOOLOGY.

“It too often happens that Zoologists know nothing of Botany; and Botanists, nothing of Zoology.” [Dutrochet, *Recherches Anatomiques*, 163.]

As we believe there is a good deal of truth in the above remark, in

whatever way it is taken, we are willing to hope that the student of botany to whom it may apply, will not suffer himself, any longer, to lie open to the imputation of zoological ignorance, but will avail himself of the aid, though but small, which the following brief and preliminary details on the subject of zoology have been intended to afford him; not certainly as a substitute for a regular course of zoological studies, wherever it is attainable; but merely as a sort of *succedaneum* in cases in which it is not attainable.

The science of Zoology, taken in its fullest extent, resolves itself into two primary and leading departments—namely, the study of Structure, and the study of Function, together with that of the habits and manners of the several species; while the study of structure resolves itself again into two secondary and subordinate departments—the External Structure of animals, and the Internal Structure or anatomy of animals. Such are the general outlines of the zoological picture; we will now proceed to add a little filling up.

PART I. STRUCTURE OF ANIMALS.

In zoology, as well as in botany, the inquirer soon finds out the impossibility of examining, or of describing, every individual singly, together with the interminable labour that it would impose upon him. But he has the same means of abridging his labours in either case;—namely, that of combining into distinct groups, or families, all such individuals as are found to exhibit a close resemblance, whether in external form or in internal constitution, and of designating them by a common appellation. We are led irresistibly to regard them as allied together by nature, and possessed of kindred qualities. This is the generalization that tends so much to the advancement of science; and that has been made, in a more or in a less philosophical way, by all systematists from the earliest time. We have seen already how it has been done in botany—that is, on the ground of aspect and of structure; let us now see how it has been done in zoology.

The structure of plants is, indeed, so essentially different from that of animals, as not to exhibit many very close or striking analogies in the comparison of their several parts; at least till you approach the bottom of the scale, and come to the Polypes and Zoophytes, which might be thought to indicate but a slight connexion between the two studies. But when we recollect that the plant, in definition, differs but little from the animal, except in the articles of locomotion and sensation; and that all animals are dependent upon vegetables, directly or indirectly, for nourishment and support; as also, that every individual species of plant of the 50,000—marine or terrestrial—which botanists now enumerate, is fed upon by some one or more species of

animal, as yielding its true and proper *pabulum vitæ*, and often damaged or totally devoured, to the great injury of the cultivator, we shall find that there is connexion enough between the two kingdoms to show that you cannot bring the study of the one to the most favourable issue without a due and competent degree of advancement in the study of the other—a consummation which the Vegetable Physiologist must, by all practicable means, endeavour to achieve.

Besides, the utility of the study of zoology, in connexion with that of botany, is further shown by its direct bearing upon other departments of science also; particularly upon that of Geology; demonstrating in the most striking manner, and in a language not to be mistaken,—that is, by means of the Fossil Remains both of plants and of animals, as deposited in their appropriate strata,—the fact of a gradual succession of changes that must have taken place on the surface of this globe, during the lapse of a gradual succession of epochas, or periods, preparatory, as well as long anterior to, the epocha of the creation of MAN. These preliminary remarks being made, we now proceed to follow up our enquiry.

In the absence of all authentic or historical detail, some, to cut the matter short, go back to Adam, with the beasts, wild and tame, submissively arranged around him [Genesis ii. 19]; the tiger playing with the kid, and the lion with the lamb; and find in the first individual of the race of men, the first classifier of animals. Others go back merely to the period of the flood, and regard as the first model of zoological classification, the arrangements made by Noah in his immense *menagerie* of the ark. [Gen. vii. 15.] Lastly, some are content to begin with Solomon, of whom we are told, not only that he spake of trees from the Cedar that is in Lebanon, even to the Hyssop that springeth out of the wall; [but] also of beasts, and of fowl, and of creeping things, and of fishes.” [1 Kings iv. 33.] Thus we find that Solomon was both a botanist and a zoologist, though he lived 3000 years ago, and M. Dutrochet would have every botanist of the present time to be a zoologist also. It is a suggestion well worthy of the attention of the student; for surely he can do nothing better than to follow the example of the wisest of men. His classes constitute a distribution taken, as it appears, from that of Moses in his account of the Genesis of animals, and founded, as we must admit, on features obvious to the most superficial observer, but not fairly or fully exhausting the subject. Whether any thing like method was introduced into the minor divisions, we cannot now learn, as we have no filling up of inferior parts. We are inclined, however, to believe that men had not yet begun to think of systems. But in the most ancient model of zoological arrangement now extant, which is that left us by Aristotle,

the celebrated philosopher of Stagira, and father of natural history, we find that the utility of method is, now, duly appreciated, and a system introduced on the groundwork of structure. Its leading characters are taken, chiefly, from the external structure, but it makes a near approach, notwithstanding, to the arrangements of nature.

Under a primary division into viviparous and oviparous,—that is, into such as produce their offspring alive, and such as produce, first, an egg,—animals are distributed in this arrangement into four classes—quadrupeds, birds, fishes, insects. It is somewhat analogous to the botanical arrangement of Theophrastus, borrowed, perhaps, from his great master, by which he distributes plants into trees, shrubs, undershrubs, and herbs;—striking, but popular, rather than philosophical. Hence many alterations were introduced into it by succeeding naturalists, as by Pliny, Gesner, Aldrovandus; but particularly by our countryman Ray, till at last the subject was taken up by Linnæus, that great reformer of systems, and brought under the scrutiny of his keen and penetrating eye. The result was that his arrangements in zoology were adopted and applauded with the same eagerness and universality as his arrangements in botany. He divides animals into six classes—mammalia, birds, amphibia, fishes, worms, insects. [Systema Naturæ, 1735.] It was a great improvement upon preceding arrangements; but still it is liable to many objections. Under the honourable and imposing title of *Primates*—the nobles of the creation, it has the misfortune to group together men, monkeys, and bats, in the same class, and in the same order; while it exhibits other incongruities equally palpable. But from arrangements founded upon the number of teeth, or of toes, what was to be expected but unnatural associations? It should be recollected, however, that his arrangements are professedly artificial, and are not to be tried by such rules of criticism as are applicable to arrangements professing to be natural. They have been reformed and improved by Blumenbach [Manual of Nat. Hist. by Gore], as far, perhaps, as they are capable of improvement; and, in their present improved state, they may be regarded as making a laudable approximation towards the arrangements of a natural system. The characters of the classes are taken, partly from the external structure, and partly from the internal structure.

But Cuvier in his *Regne Animal*, and Carus in his introduction to the Comparative Anatomy of Animals, have established a new principle of arrangement, and have shown to the satisfaction of zoologists that all characters of classes truly natural must be taken from the internal structure only, as exhibiting, most distinctly, the several *grades*, or several degrees of excellence, that exist among animals, whether as relative to sensation or to locomotion;—the very essence

of animality, and measure of animal perfection. This principle is in keeping with that of the arrangements of Jussieu in botany, and may be followed up either in the order of the ascending or of the descending scale, according to the peculiar object of the investigator. Carus adopts the first of the two modes, and ascends from the lowest and minutest animalcules up to man. Cuvier adopts the second of the two modes, and descends from man to the meanest entity endowed with animal life. His leading and primary divisions, which have been very generally adopted, are the four following:—

The first and highest division of the animal scale includes man and the animals resembling him most nearly in the form and complexity of their internal structure. The leading character on which it is founded is, that the brain, and the chief trunk of the nervous system, are enclosed in bony coverings; the former in the *cranium*, the latter in the *vertebræ*, or joints composing the back-bone, to the sides of which, the ribs, and the bones composing the limbs, which are four in number, are attached, forming the skeleton or carpentry of the body. Animals of this description are said to be vertebrate—*Vertebrata*. They have red blood, a muscular heart, a mouth—the origin of the intestinal canal, with two horizontal jaws, and distinct organs of sight, smelling, hearing, tasting, situated in the cavities of the head; a generally diffused tact, or circumscribed touch; the locomotive muscles attached to bones; the *viscera* lodged in the head and trunk; the head distinct from the body; and the sexes in separate individuals. Of this general model there are many varieties, the descending gradations of which may be very easily traced, from man to the meanest reptile.

The second division of the descending animal scale includes the *Mollusca*—namely, individuals which consist of a soft and gelatinous mass, and exhibit a structure less complex than that of the *Vertebrata*. The body is without a skeleton, and without a distinct head, the muscles being attached to the skin, that forms a soft and contractile covering, which in many species is incrustated with a shell, in which envelope the *viscera* are contained, together with the nervous system under the form of scattered masses of threads. The chief of these masses lies in or round the *æso-phagus*, and is called the brain. Of the senses common to the *vertebrata*, beyond that of feeling, they seem to possess only taste and vision, with the exception of one family—the *Sepiæ*, which exhibits organs of hearing also. But they have an apparatus for circulation, respiration, digestion, and secretion, scarcely less complicated than that of the *vertebrata* themselves.

The third division of the descending animal scale is that of worms, and insects designated by the appellation of articulated animals—*Ar-*

ticulata; exhibiting a structure, as Cuvier seems to have thought, less complicated than that of the *Mollusca*. Their nervous system consists of two cords extending along the belly, and expanding at regular intervals into knots or ganglia. The first of these, placed on the œsophagus, is called the brain, though not much larger than the rest. The covering of the body—in some species soft, in others hard—is divided by transverse folds into a certain number of rings, with the muscles attached to the interior; hence their appellation of *Articulata*, or, as Mr. M'Leay would rather call them, *Annulosa*. Many of them have lateral and articulate limbs originating in pairs, while others are destitute of limbs. They have not a real circulation, except, says Kirby, the *Arachnida* and *Annelida*. [Introd. to Entom. iv. 80.] They have not lungs, but spiracles. They have organs of taste and sight, with the jaws, if any, lateral; and a single tribe, *Crustaceæ*, has the organ of hearing.

The fourth and lowest division of the descending animal scale, including the zoophytes of preceding naturalists, Cuvier now designates by the appellation of radiate animals—*Radiata*. They exhibit the greatest simplicity of animal structure, and a peculiarity of conformation that cannot be mistaken. In the foregoing divisions the organs of motion and of sensation are found to be symmetrically placed on two respective sides of a certain axis. In the *Radiata* the corresponding organs are arranged in rays around a common centre, and hence their appellation of *Radiate*. The subjects of this division approach, in some degree, the homogeneous character of plants. They have no nervous or muscular system that is so clearly or so distinctly marked as that of the *Articulata*; though in a few of them you may trace some faint vestiges of a circulation, with respiratory organs on the surface of the body. In the *Polypi* the intestines are a mere bag without passage; and in the *Infusoria*, the lowest in the animal scale, the individual was till lately regarded as a mere mass of homogeneous pulp endowed with motion and feeling, but devoid of all organs whether external or internal. But this view of the subject has been shown to be erroneous; and in the order of the above arrangements we now proceed to exhibit a hasty and partial sketch, first, of the external structure of animals, and, secondly, of the internal structure, or the anatomy, of animals.

I. THE EXTERNAL STRUCTURE OF ANIMALS.

DIVIS. I.—THE VERTEBRATA.—Of the animals of this division some are viviparous, and furnished with teats by which they are enabled to suckle their young: this is the class of the *Mammalia*. Some are oviparous, and adapted by their structure to the act of fly-

ing: this is the class of birds. Some are destined to live in water, and are adapted by their structure to the act of swimming: this is the class of fishes. Some are doomed merely to crawl upon the earth, and to pass a great part of their existence in a state of stupor: this is the class of reptiles.

Class 1.—If an individual of the class *Mammalia* is taken and surveyed externally at the period of its perfect developement, it will be found to be composed of a head, a neck, a trunk, and limbs. We will take our view of these parts as they occur in man, who stands, incontrovertibly, without a rival at the head of the animal creation, not merely as the first in the first rank, but as constituting an order of himself, into which no other genus is worthy of being admitted, and as exhibiting a fabric that we cannot but regard as the most perfect model of animal organization.

In surveying this model, the first thing that arrests our attention is that most remarkable and striking peculiarity, connected with, and dependent upon, structure, by which man is at one glance distinguished from all other animals whatever, and elevated, as it were, on an eminence to which they can never attain,—namely, that of his upright or erect posture, through means of which, while other animals look prone upon the ground, we raise our face to heaven to contemplate the throne of God. Ovid, the sweetest of Latin poets, has described this distinguishing attribute of man in language peculiarly felicitous:—

“ Pronaque cum spectent animalia cetera terram,
Os homini sublime dedit, cœlumque tueri
Jussit, et erectos ad sidera tollere vultus.” MET. Lib. i.

Milton, also the loftiest and most sublime of British bards, whose epic rank and dignity is second only to that of Homer and of Virgil, has been equally felicitous with Ovid in his description of the dignity of the human form:—

“ Two of far nobler shape, erect and tall,
Godlike erect, with native honour crown'd,
In naked majesty, seemed lords of all.”

PARADISE LOST, Book iv.

Of this noble and dignified structure the portion that claims our first notice is the head—the capital that crowns the fabric. Its elevated position; its ample expansion of countenance, the index of the operations of mind; its rounded and globular form; its comely covering of hair, hanging in the unadorned loveliness of nature, or modified by the *contrivances* of art; and its serving as the seat of almost all the organs of sense; are prerogatives that entitle it to our peculiar consideration. If we look at its elevated position, we shall

find that the head assumes, as it were, the post of honour, being placed above all the other portions of the fabric, and hence giving the necessary elevation to the organs with which it is furnished; but particularly to the organs of vision, by which we can thus command a wider and more extended view of the glories of external nature. Had man been destined to walk or to stand on all-fours, as some philosophers have presumed that he originally was, he would have been in a much worse condition than any of the quadrupeds, whose look, though prone, is still well suited to their form and condition; for in that case his face would have been depressed to a parallel with, and even to an angle beyond, the level of the horizon, and his look turned neither forwards nor backwards nor to the one side, but directly downwards. It could not have been then said that he was made to contemplate the heavens. But the inequality that is so notoriously evident in the length of our legs and arms, together with their mode of articulation and flexure, affords proof sufficient that nature never intended man either to walk or to stand except on his feet only, and that for the purpose of giving elevation to the head.

If we look at its expansion of countenance, we shall find that the head most nobly vindicates its pre-eminence over all the other portions of the human fabric, and conspicuously exalts the dignity of man. The amplitude of the forehead; the expression of the eyebrow; the fire and brilliancy of the eye; the bold and manly, or the delicate and feminine, profile of the nose; the blush and dimple of the cheek; the witchery of the smile, and the lovely contour of the chin,—are attributes of man's countenance that are palpable to every one, and are the perpetual theme of the admiration whether of the lover or of the philosopher. To this we ought also to add that interminable diversity of feature and of lineament so remarkable in the human face, that out of the countless millions of mankind, possessing all that closeness of resemblance, and all that striking similitude of form, that are necessary to determine the species, or even the variety, no two individuals have ever yet been found so exactly alike as to make it a matter of any great difficulty to distinguish the one from the other.

Philosophers reduce the peculiar traits of countenance that characterize the several races of mankind into certain manifest varieties, of which the following are the most important:—1. The Caucasian, whence the European variety: Countenance oval; features delicately blended; forehead high and broad; nose aquiline; cheek bones not prominent; complexion fair.—2. The Mongolian variety: Face broad and flat; nose flat; space between the eyes wide; chin prominent; complexion olive.—3. The American variety: visage broad, but not

flat; cheek-bones prominent; forehead short; eyes deeply fixed; nose flattish, but prominent; complexion red, or of a copper tint.—4. The Negro variety: Face narrow, projecting in the lower part; forehead narrow, retreating, arched; eyes prominent; nose and lips thick; complexion black.—5. The Malay variety: Face not so narrow as in the negro, projecting downwards; nose bottled; mouth large; complexion tawny. [Blumenbach, by Elliotson.]

If we look at its rounded and globular form, we shall perceive that the human head has a grace and beauty conferred upon it that do not belong to any other form peculiar to any other animal; and even in man the varieties having most of the globular form have the most of beauty. This will appear very plainly if the investigator will take the trouble to compare the Caucasian variety with that of the other four varieties, either in the actual *crania* of dissected subjects, if he has access to such, or in the drawings with which anatomists have supplied us. The head of the Georgian female is regarded, by Europeans at least, as the most perfect model of human beauty. It is the most globular of all the varieties, and is generally adduced as an example of the most exquisite of capital forms. In the other varieties, but particularly in that of the negro, the forehead is so much flattened, and the lower part of the face—the mouth and jaws—so much protruded and elongated, as to suggest the degrading idea of a snout or muzzle; lowering in our estimation excessively the pretensions of the negro head, whether to grace or to beauty. Physiologists have even instituted a standard of perfection with regard to the form of the head, which they find in the facial angle of the Caucasian variety. Viewing the head in profile when the body stands erect, draw a line from the greatest projection of the forehead to the upper maxillary bone: this is the facial line. From beneath the basis of the nostrils draw a horizontal line meeting the facial line. This junction gives the facial angle [Blumenbach, by Elliotson, 388], and the measure of the relative projection of the jaws and forehead. The nearer it approaches to a right angle, or, in other words, the less prominent the jaw, the more perfect is the form, and the greater the presumed sagacity of the individual. But if the head of the negro will not bear comparison with that of the Caucasian, much less will the head of any of the inferior animals bear it.

If we look at its comely covering of hair, we shall find in that peculiarity also another source of beauty. Among Europeans, Eastern Asiatics, and Northern Africans, the hair of the head grows to a great length, particularly in females. We have known it to exceed the length of three feet. Its colour is black, brown, or red, according to climate, or to other contingencies. On the fore part of the head it falls towards the brow;

on the back part, towards the neck; and on the sides, towards the shoulders. It is very ornamental, and admits of being done up in a great variety of ways, so as to please all tastes and all fancies:—

“ Cui flavam religas comam
Simplex munditiis.”

HOR. Lib. I. Ode v.

Yet sometimes crops are the fashion, and sometimes wigs; but nobody chooses a red wig, as I believe. There seems, indeed, to be a prejudice against red hair in any shape whatever. It is alleged, but how truly I cannot say, to have some intimate connexion with the temperament of the body, causing a foetid or disagreeable odour. In man, black hair is supposed to be expressive of strength; in women, of vivacity; whilst in woman the blond is thought to be expressive of delicacy, and in man of I know not what that is devoted to pleasure; so says Bichât. [Anat. Gener. Syst. Derm.] The beard is peculiar to males. Christians shave it; Jews suffer it to grow. It appears at the age of puberty, of which it is a sign. It is shorter than the hair of the head, as well as more given to curl; and its colour is generally either black or red.

Lastly, if we regard the head as being the seat of the organs of sense, we shall find its pre-eminence over all the other parts of the human fabric to be most signally demonstrated. 1st. As containing the eye, the organ of vision, which, stationed like the sentinel in his watch-tower, surveys from its lofty height the objects placed around it, and unfolds to the individual the beauties of the external world. Cicero seems to have been duly impressed with a conviction of this truth when he wrote the following sentence:—“ *Nam oculi tanquam speculatores, altissimum locum obtinent, ex quo plurima conspicientes, funguntur suo munere* [De Nat. Deor.]—“ For thus the eyes, placed like sentinels on a watch-tower, discharge their function, with an extended sphere of vision.” 2nd. As containing the ear, the organ of hearing, calculated to receive the impression of sounds, to give us notice of the approach of external objects, and to enable us to appreciate the value of tones, whether they be the modulations of music, or the articulation of a spoken language. 3rd. As containing the nose, the organ of smell, and source of balmy delights, projecting, as Haller observes, like an engine in the air [First Lines by Cullen, sect. 465], to arrest and collect the perfumes, sweets, and odours that are exhaled from the treasures of Flora, and wafted on the winds. 4th. As containing the tongue, the organ of taste, and with the mouth, the arbiter of savours, discriminating between the clean and the unclean, the noxious and the wholesome, the production that is good for food, and the production that is to be rejected; as well as forming a principal

part of the apparatus of speech, the distinguishing attribute of man. 5th. As possessing, in common with all the rest of the surface of the fabric, the general attribute of tact, which exists, however, in the highest degree only in the palms of the hands, and at the ends of the fingers, and is there denominated touch. Finally, besides being the seat of the organs of sense, it is also the seat of intellect, as is indicated by our own internal convictions, leading us irresistibly to the conclusion—that thought has its residence in the head. The head thinks.

The second portion of the fabric of the human body is the neck, which we may regard as the shaft or column that supports the grand Corinthian capital of the head, in the base of which it originates. In man it assumes a circular and columnar form, possessing great natural grace and beauty. Anacreon exhibits a fine idea of its fascination, in his instructions to the artist who was about to take the portrait of his female friend:—

“ Τρυφεροῦ δ’ ἔσω γενείου
Περὶ λυγδίνῳ τραχήλῳ
Χάριτες πετοῖντο πᾶσαι.”

Ode xxviii.

“ Under her beautiful chin, around her *snowy neck*, let all the Graces be fluttering.” The description was no doubt suggested by the original from which he drew; but, in addition to its native loveliness, the neck admits also of such artificial ornaments as may be suggested by the fertile fancy of the arbitresses of female fashion. “Thy cheeks are comely with rows of jewels; thy *neck* with chains of gold.” So said the wisest of men. [Canticles. i. 10.] It possesses, besides, a peculiar flexibility, by which the movements of the head are multiplied and facilitated extremely, as well as rendered peculiarly elegant and expressive. Tapering delicately, towards the middle it begins to expand, till it ultimately rests upon the shoulders, and forms the connecting link between the head and the trunk. In quadrupeds, though it does not always assume the circular form, still it possesses much beauty. “Hast thou given the horse strength? hast thou clothed his *neck* with thunder?” [Job xxxix. 19.]

The third portion of the fabric to be noticed in our present survey is that of the trunk or body, which we may regard as the base or pedestal that gives bulk and stability to the individual, with support and attachment to the neck and head, as well as to the several limbs. It is divided superficially into certain peculiar regions—the back, the sides, the shoulders, the breasts, the abdomen. The greatest bulk or circumference of the body lies within a line encircling the breast; but in a high state of corpulence or *embonpoint*, the greatest circumference may lie within a line encircling the abdomen, as in the case of Falstaff’s waist, according to Shakspeare:—

“*Fal.* My honest lads, I will tell you what I am about.

“*Pist.* Two yards and more.

“*Fal.* No quips now, Pistol ; indeed I am in the waist two yards about, but I am now about no waste. I am about thrift.” [Merry Wives of Wind. Act I. s. 3.]—a rare thing for Falstaff to be about, and worthy of special notice. In the body, as in the head and neck, you may readily trace a medial line, having similar parts or organs on each side, on the right and on the left ;—the two eyes, the two nostrils, the two ears, the two shoulders, the two breasts, the two sides. The medial line of the trunk is displayed most conspicuously in the back, following the course of the back-bone, and in most of the vertebrata terminating in a tail, of which men and some monkeys are destitute.

The fourth and last portion of the fabric is that of the limbs, or organs of locomotion. In the Mammalia, as indeed in all vertebrate animals, where limbs are present, they are almost always four in number ; and upon the principle of duality, and of a right and left side, which we have just recognised, they go in pairs—two fore limbs, and two hind limbs. In man, the two fore limbs are composed of the arms, the fore arms and the hands. The arms extend from the shoulder to the elbow ; the fore arms from the elbow to the wrist ; and the hands from the wrist to the tips of the fingers. Each hand is composed of a *metacarpus*, or body constituting the back and hollow of the hand, together with four fingers and a thumb,—the thumb being so placed as to stand in opposition to the fingers, and thus greatly to facilitate the grasping or holding of small bodies. The palms of the hands and the ends of the fingers are peculiarly the seat of touch, to which the nail, placed only on the one side of the extremity, affords a kind of support. No other animal possesses an organ of touch so perfect as that of man. The hand of apes makes the nearest approach to it, but it is far from reaching its perfection of form. Even the hand of the Orang-Outang, the most perfect of apes, is too long in proportion to its width ; and the thumb, which scarcely reaches to the root joint of the fore finger, too short and too inefficient, and too little suited to be put in opposition to the fingers, to bear a comparison with that of man. The two hinder limbs are composed of the thigh, the legs, and the feet. The thighs extend from the hip to the knee ; the legs from the knee to the ankle ; and the feet from the ankle to the tips of the toes. Each foot is composed of a *metatarsus*, or body constituting what we call the back and sole of the foot, which terminates in five toes,—the great toe, the little toe, and the three middle toes, all placed on the same level, so that the great toe cannot be opposed to the other toes, as the thumb is opposed to the fingers of the hand—a conformation evidently in keeping with the erect posture proper to man, as being

calculated to enable him to stand, or to walk firmly on the soles of his feet, and to leave the hands and arms at liberty. Whereas the hinder limbs of apes may be said to end in hands rather than in feet, and to have palms and prehensile fingers, rather than soles and toes, which, when placed upon the ground, rest not on a broad and duly flattened surface, like the sole of the human foot, but merely on the external edge of the organ, and hence present no proper basis of support to uphold the fabric in an upright position. Thus, man is the only two-handed animal that exists, for apes are in fact four-handed, as the foregoing details exhibit them, and are hence duly entitled to the epithet—*Quadrumana*, or four-handed, by which they are now designated [Regne Animal], and by which the difficulty that puzzled Linnæus has been at length removed. “Nullam characterem hactenus eruere potui unde homo a simiâ internoscatur”—“I have not hitherto been able to discover any mark by which men may be distinguished from monkeys.” If other proofs were wanting to show the superiority of men to monkeys, it would be easy to adduce them. They are destitute of speech; they are destitute of intellect. What is this owing to? Camper, who dissected an Ourang-Outang, found in the front part of the neck two bags or cavities communicating with the *trachea*, which seemed to him to be incompatible with distinct articulation. After all, it is doubtful whether the bags in question form an absolute bar to speech. Mr. Laurence thinks they do not, and regards the total incapability of apes to generalize their ideas, or pursue a consecutive train of thought, as being the only true bar that lies between them and speech. Thus the grand cause of their inability to form a spoken or articulate language is placed beyond the reach of anatomical detection, and is apparently owing to their want of intellect. Sir Charles bell regards their inability to articulate as resulting not merely from want of intellect, but from want of due organization also, or of the due complement of nerves necessary to associate the several organs in one act of vocality. [Bell on the Human Hand.] Why they are destitute of intellect, though furnished with an organization approaching to that of man, it is not our present business to inquire; but facts show us that they are so. How else are they so totally incapable of education? the Ourang-Outang and Chimpanzé have even been admitted, by way of experiment, into human society; but they have shown no disposition to adopt the habits and manners of men; and, though full of trick and mimicry at times, can never be taught to imitate the articulate tones of the human voice. Besides, they have no relish for the society of men, and remain, even in the midst of mirth, “for ever silent and for ever sad.” Hence, though we may fairly say of them, “*Mens agit at molem*” [Virgil. *Æneid*. VI. 727], yet we cannot say that it is the *mens divini*or, which is proper to man.

In quadrupeds the feet are four in number, as the name imports. They are single and undivided, as in the horse; or they are divided into toes, of which some genera have two, as the ox and goat; and some more than two, as the hog and elephant, while others have the toes united by means of an intervening membrane, and have hence obtained the appellation of web-footed, as the otter. The limbs, whether anterior or posterior, will be found to exhibit a distant analogy to the type of man, if we look at and compare the same joints.

Class 2.—If we look at an individual of the class of birds, we shall find that it exhibits the same general type of structure with that of the *Mammalia*, consisting of head, neck, body, limbs. The head, as in the foregoing class, is the seat of the organs of sense, furnished with, and terminating in, a bill, by which the individual picks up and breaks its food. The form of the bill differs much in different species, and serves as a mark to discriminate tribes or families. The head, neck, and body are covered with feathers, which are often adorned with the brightest and most brilliant colours. The neck assumes the circular form, and often displays peculiar beauty, as well as peculiar flexibility, as any one who has seen a swan in the act of swimming will, with Milton, readily admit:—

“ The swan with *arched neck*
Between her white wings mantling, proudly rows
Her state with oary feet.” PARADISE LOST, B. vii.

The greatest bulk of the body is around the breast, tapering towards the tail, which is composed of feathers of a peculiar form,—magnificently illustrated in the tail of the Peacock, and bird of Paradise. The fore limbs assume the position and fan-like form of wings, to fit the individual for its flight in air; and are often composed of, or rather covered with, a plumage that is most splendidly brilliant. The hinder limbs always terminate in feet, divided into toes tipped with claws; some genera having the toes separate, as the pheasant and partridge; and some having them united with a membrane, as the swan and goose. The former are land birds; the latter are web-footed, or water birds.

Class 3.—In this class, the class of fishes, the vestiges of the general type, though much metamorphosed, can still be readily traced. The head is very distinctly visible, furnished with projecting mouth and devouring jaws. The eyes are sufficiently conspicuous; but the other organs of sense have no very visible developement of external parts. The head is joined to the body without the intervention of any distinct portion of the fabric that can properly be called a neck; but about the junction of the head and body, we find on each side an

external organ which is peculiar to fishes; namely, the gills—their organ of respiration. The body, which is covered with scales, is rounded, and tapering from head to tail, as in the eel; or a little flattened in a vertical direction, as in the trout and salmon; or much flattened in a horizontal direction, as in the sole and flounder, and in all flat fish. The limbs, whether anterior or posterior, are metamorphosed into fins, to fit them for the act of swimming in water. By the lateral flexion and extension of the caudal fins the body is impelled forwards with great force, ascending or descending chiefly by means of the compression or dilatation of the swim-bladder, an organ with which most fishes are furnished; but such as are destitute of it, like soles and flounders, must be content to swim very near the bottom. Some fishes have the capacity of leaping out of the water; and some, as the several species of *Exocoetus*,—the true flying fish,—have the very singular property of being able to take a short flight even in air.

Class 4.—In this class, the class of Reptiles, the general type is in most cases very obvious, exhibiting a head with a mouth and eyes distinct; a visible neck; a body naked, as in the frog; or covered with a shell, as in the tortoise; without a tail, as in the toad; or furnished with a tail, as in the lizard. The limbs, anterior and posterior, are so excessively short as scarcely to be able to raise the body above the level of the ground; and in the order *Serpentes* even limbs are wanting. Many of the *Reptilia* are amphibious, and can live either on land or in water; and most of them, during the winter months, sink into a state of torpidity, from which they are aroused only by the returning warmth of the succeeding spring.

DIVIS. II.—THE MOLLUSCA.—The next division of animals in the descending scale is that of the *Mollusca*. They are distributed into three classes,—the *Cephalopoda*, in which the feet, or organs of locomotion, are inserted in the head; the *Gasteropoda*, in which the foot, or organ of locomotion, is the abdomen; and the *Acephala*, in which no distinct head is visible. In each class there is an order that is enclosed in a shell, or testaceous covering, and an order that is naked.

Class 1.—In the first class we find the Sepiæ, or Cuttle-fish. They are of the order of naked Mollusca, and in their general aspect are but a shapeless mass. The head, however, is distinctly visible, furnished with eyes, and organs of hearing, as well as with presumed organs of smell, from the fact of their aversion to strong-scented plants. [Carus. Compar. Anat. i. 74, by Gore.] Around the head there are fixed a number of arms, which are the organs of locomotion and of prehension. In *Sepia officinalis* they are ten in number, two of them being longer than the rest. The arms are furnished with suckers in the shape of excavated tubercles, by which the individual can fasten

itself firmly to external substances, and thus stand, as it were, upon its head. It is further remarkable for a peculiar and lens-shaped bone, called the Cuttle-bone, of a calcareous texture, that lies embedded in the back, or fleshy part of the body, and is so light that it swims in water. It is applied to various useful purposes in the arts, and makes a very good tooth-powder. The *Sepiæ* have also the singular property of ejecting at pleasure, from the abdomen, an inky-coloured fluid, that darkens the water in their vicinity, and renders them for a time invisible to their pursuers. They are not uncommon on the coast of England.

Class 2.—In the second class we have the slug—*Limax ater*—that infests our gardens and corn-fields during the spring and summer, devouring the radicle, or the cotyledon, or the tender blade of the young plant, and blasting the golden hopes of the too sanguine cultivator. The largest slugs of this species, when fully extended, may be about the size of a finger. The head is furnished with a mouth, by which the individual gathers its food; and with a pair of horns, or feelers, terminating each in a black point, which is regarded as an organ of vision. It slides along upon its abdominal surface by a sort of vermicular movement, leaving a slime behind it; and it has the capacity of contracting its extended body into a very small compass, if affected by fear, or hastily interrupted in its peregrinations.

Class 3.—In the third class we have the oyster—*Ostrea edulis*—in its shell the delight of the *gourmand*, or connoisseur in sauces, and so well known to every lover of good things as scarcely to stand in need of any description. It belongs to the order of acephalous bivalves, having its abode in the ocean, but choosing as its favourite habitat the mouths of rivers or of estuaries. It sheds its spawn in the month of May, on rocks and stones, or other substances at the bottom of the water, to which the young brood clings till detached by the industry of the dredger, to be transported to beds calculated to forward their growth and give additional delicacy to their flavour. The oyster seems to be destitute of all organs of locomotion, and yet it is capable of changing its place. By opening its shell to a certain width it takes in a portion of water, which it has the power of squirting out again with considerable force, and of thus propelling itself to any practicable point in a direction contrary to that of the force exerted.

DIVIS. III. — THE ARTICULATA.—The third division of animals in the descending scale is the *Articulata*, which have the body externally divided into a succession of rings, or articulations. They are distributed into the three following classes:—The *Vermes*, or worms, in which the body is without any external organs of locomotion; the

Crustacea, in which the body is covered with a shell; and the *Insecta*, or insects, in which the body is divided, by deep indentations, into four principal parts—the head, the corselet, the chest, and the abdomen.

Class 1.—The first class is exemplified in *Lumbricus terrestris*—the earth-worm. At its mature size it may be about a span in length, with the circumference of a goose-quill. The head is indistinct, but the mouth is not so. The body is soft and gelatinous, and articulated on the external surface; with a sense of touch chiefly about the two extremities; but without any external and distinct organ whether of hearing or of sight; and without feet, but covered with projecting bristles, or tufts of hair, which in some measure supply their place.

Class 2.—The second class is exemplified in the crab and lobster, shell-fish that are well known. They inhabit rocky shores, or shallows of the ocean, and feed upon sea-weed and all manner of garbage. The head is furnished with feelers, and with moveable eyes. The legs are eight or ten in number, with five articulations, the first pair ending in claws or nippers, and, like the body, covered with shell. If they lose a limb by accident, they have the power of reproducing it. Lobsters have a long and articulate tail, covered with a horny coat, composed of several portions that move one upon another. They shed their shells annually, and screen themselves for a few days under the shelter of stones and rocks till the new shell is sufficiently indurated to defend them from the ordinary accidents to which the element they inhabit exposes them. At last they are caught by the art of the fisherman, and forwarded to the tables of lovers of luxuries, where they are much esteemed for the delicate morsel, or for the rich and piquant sauce, which their edible portion affords. The natural colour of the lobster is black; but when boiled it changes to red—a fact that the author of “*Hudibras*” has turned to good account in the getting up of one of his ludicrous similes:—

“ The sun had long since, in the lap
Of Thetis, taken out his nap ;
And, like a lobster boiled, the morn
From black to red began to turn.”

HUDIBRAS, Part ii. Canto 2.

Class 3.—The third class is exemplified in the silk-worm—*Phalæna Mori*. In its native country of China, or of India, it lays its eggs in summer, on the boughs of the mulberry-tree. They are small yellow globules about the size of a millet-seed, and a single female will lay several hundreds of them: but where such trees are not to be found, as in the case of the transporting of the species into other climates, the female will lay her eggs on whatever substance she may

happen to have access to. To this substance they remain agglutinated during the winter that succeeds, and begin to be quickened by the return of spring, till, in the month of May, they are evolved into life,—that is, as kept in the cabinets of the curious of this country. The protruded insect is now a caterpillar of a very diminutive size, consisting of a head, a mouth, and a body composed of seven rings, and furnished with the same number of feet on each side. If well fed with mulberry leaves, it will grow very rapidly, and in the course of five or six weeks will have attained to its full size—that is, to a length of nearly two inches, with a diameter equal to that of a goose-quill. It now sickens and refuses food, and sheds its skin; revives, and feeds, and sickens, and sheds its skin again, and again; and on its third or fourth revival selects, after a day or two of indecision, a suitable spot for future operations, and begins to weave its cocoon, which it completes in about a week. Imprisoned in its cocoon, it puts off the caterpillar form entirely, and is metamorphosed into a *chrysalis* or *pupa*, in which state, and from which prison, after a sojourn of another week, it cuts or forces a passage out, and is ultimately transformed into an *imago*, or moth, not adorned with brilliant colours, but exhibiting in its form and structure much of beauty and of elegance, and of an *indescribable something* that seems to indicate its Oriental origin. In this state it lives three or four days, occupied in the process of propagating the species; and, this done, it dies.

DIVIS. IV.—THE RADIATA.—The fourth and last division in the descending animal scale is that of the *Radiata*, including the zoophytes of the earlier botanists, whose leading character is, that they have their parts or organs arranged in a radiant or divergent direction around a common centre. The division forms a group consisting of the five following classes:—1st. *Echinodermata*,—the body enclosed in a crustaceous covering, beset with spines. 2nd. *Medusæ*, or sea-nettles,—the body soft and gelatinous, stinging the hand that touches it, and the mouth furnished with *tentacula*. 3rd. *Corals*, *Corallines*, and *Sponges*,—the body covered with a shell-like, or stony, or horny crust, or surrounding an insensible stalk—*stirps radicata*, attached—the mouth furnished with *tentacula*. 4th. *Polypi*,—the body a bag of jelly, pedicled, or without a pedicle, but unattached,—*stirps libera*, *corpus liberum*,—the mouth furnished with *tentacula*. 5th. *Infusoria*,—the body a gelatinous globule, furnished, as it was thought, with no external organ or orifice whatever, and, what was more extraordinary still, with no internal organ, till the recent discoveries of Ehrenberg were laid before the public, by which their true structure has been at last demonstrated. Professor Grant has shown that the classes arising out of this division may be

increased with advantage to the science; but those we have adopted are sufficient for general purposes.

Class 1.—The first class is exemplified in the genus *Asterias*, or Star-fish, with its five radiating lobes; or in the genus *Echinus*, or sea-urchin, with its thousand spines. These genera are common on the shores of England; and when the enclosed animal dies, the empty covering is often to be met with lying on the sea-beach, as it may have been accidentally thrown up, and left by the flux and reflux of the tide.

Class 2.—The second class is very beautifully exemplified in the genus *Actinia*—animal flower, or sea anemone. It is found in great abundance on the coasts of the West India islands. It is club-shaped, fig-shaped, or cylindrical, and fixed by the smaller or lower end to rocks, or to stones lying in the sand. To this mode of attachment *Actinia Sociata* is an exception, the foot being fixed, not immediately to the rock, but to a firm and fleshy tube that creeps along horizontally and sticks fast to the surface, resembling in some degree the *souche souterraine* of Common Brakes. At the upper extremity there is a single opening, which is the mouth, leading directly to the stomach, which is a blind sack. The tentacula, when expanded, are said to exhibit an appearance similar to that of the petals of the *Anemone*, whence the name. They are tinged with a variety of bright and brilliant colours, and are the instruments which the animal employs in the seizing of its prey. The *Actiniæ* are very voracious. They will swallow a muscle or oyster entire; and after having extracted the internal nutriment by the digestive power of the stomach, they will again eject the shell by the same aperture at which it entered. They are also remarkable for their capability of being multiplied by division to any extent. Cut up a single individual into a thousand pieces, and each piece will become a complete *Actinia*, furnished with all the peculiarities of its species. [Encyclop. Brit. Animal Flower.] This singularly curious animal is found also on the coast of Great Britain, and was lately discovered, as it is said, growing in great abundance on the sunken and sand-covered deck of the Royal George, when the diving-bell was let down to have the wreck surveyed.

But examples occurring more frequently on the shores of the British Isles will be found in the several species of the genus *Medusa*, better known, perhaps, by the vulgar appellation of sea-blubber. They are of a globular form, of a soft and pulpy consistence, and of a shining pale blue colour, dashed with a tinge of violet. You may see them approaching the coast with a flood tide, floating or drifting on the surface of the wave, sometimes singly, and sometimes in multitudes, under the semblance of a large lump of jelly,—in *Medusa aurita* not

less than three or four inches in diameter,—with their tentacula spreading around them. They emit a 'phosphorescent light in the night, and, when voyaging in large shoals, illuminate the surface of the deep. They sting the hand that touches them, and cause a tingling pain.

Class 3.—The third class includes corals, corallines, and sponges, in which a sensitive body surrounds an insensible stalk, or is enclosed in an insensible covering,—stony, crustaceous, or horny; not constructed by the animal itself, but congenital with it; not phosphoric, but calcareous,—*stirps radicata*, attached. The former varieties occur in the *Gorgoniæ*, the latter in the *Tubiporiæ* and *Celleporæ*.

Class 4.—The fourth class is that of the Polypi, the body being a mere bag of jelly attached to a *stirps libera*, as in the sea-feather, or wholly unattached, *corpus liberum*, with arms radiating from the mouth; and with the power of attaching itself, by the opposite extremity, to any object at pleasure. Some of them you may turn inside out, like the finger of a glove, and the animal shall still live. You may cut them into as many pieces as you please, and each piece will become an entire animal. *Hydra viridis* is a good example.

Class 5.—Finally, the fifth class is that of the *Infusoria*, which seem to consist merely of a small and pulpy globule, capable of a brisk and spontaneous motion, but apparently furnished with no external organ whatever,—till the application of a high magnifying power discloses their true structure. If a drop of water taken from a ditch or pond in which vegetable substances are becoming putrid, or if a drop of rain water that has stood exposed to the weather for several days, is put upon the stage of a good microscope, and the eye applied to it, you may see hundreds of them frolicking in that single drop, like fishes in the ocean.

Thus, in animals as in plants, life assumes a great variety of different aspects, according to the tribe or family in which we contemplate its phenomenon; and thus a scale of degrees, from man downwards, is evident, even from the contemplation of the external structure. In man you have the several parts of the body the most distinctly marked,—the head, the neck, the trunk, the limbs; and the organs of sense the most fully developed,—the eye, the ear, the nose, the palate, the touch; with the peculiar conformation of the foot, and of the head,—the former serving as a basis to support the body in the erect posture, and the latter as an instrument adapted to the thousand different purposes for which man may have occasion to employ it,—whether in the fine arts, as in music, drawing, painting, sculpture; or in the domestic arts, as in the fabrication of clothing, or the construction of machinery; or as in the operations of agriculture; or of war, whether

military or naval; or as in the manipulations of chemistry, or of anatomy; or, finally, as in almost every art or exercise that man has occasion to perform. Apes, though furnished with four hands, have no hand equal to that of man. If they had the hand, they have not the skill to direct it; and if they had the skill, they have not the hand.

With Quadrupeds the case is still worse. From their size and the structure of their fabric, many of them have greater strength or greater swiftness than man; but they have no hand. A hoof is but a very inadequate substitute for it; and even with all the advantages of mind, man would be nothing without the master instrument of the hand. Birds, fishes, and reptiles, are, by their organization, removed still further from man than even quadrupeds; while the other divisions of the animal kingdom—the *Mollusca*, the *Articulata*, the *Radiata*—are removed even farther still. For to whichever of them we direct our regard, we find, in their external structure, nothing that approaches to the type of man, nothing that is fit to be compared to the fabric of the human body, and nothing that equals the capabilities of its several organs, whether for the purposes of sense, of prehension, or of progression; but rather an increased dissimilitude of structure, in proportion as you approximate the bottom of the scale, till at last you reach the minute and microscopic, but brisk and agile animalcule, that wheels and frolicks in its drop of fluid, as if its organs of locomotion were of the first and most perfect order. Thus man stands without a rival at the head of the animal creation—the image of his Maker,—“the noblest work of God!”

II. THE INTERNAL STRUCTURE OF ANIMALS.

The science of physiology is founded in anatomy. We cannot attain to the *rationale* whether of vegetable or of animal function without a correct knowledge of the mechanical structure of the several organs of which the fabric is composed. Hence every physiologist is of necessity an anatomist, who is presumed to have made himself well acquainted with the organs in question; viewing them in all their bearings, and in all the intricacy of their composition, and leaving nothing untouched that relates to use or to structure;—a work, as will readily be admitted, of indescribable difficulty, and of incredible labour, particularly as it regards animals, in which we cannot expect that many men will engage themselves except with a view to medical or to surgical practice. Yet there is a certain degree of anatomical knowledge—

“Est quodam prodire tenus, si non datur ultra.”—HOR. EPIST. I. Lib. i.

that it may be desirable to possess, and that some men—men of leisure,—may be desirous of possessing without any professional view. Thus

a man might be desirous to know, of what, and of how many bones a human skull is composed, without becoming an anatomist; or even to make himself acquainted with the various processes, holes, depressions, or indentations, which they may severally exhibit, and which could not be well done except through the usual means of a regular course of anatomical education.—But if not the names, much less the uses. Say that the stimulus prompting him is mere curiosity. There is no harm in gratifying it; and all that he desires to know, he may acquire, if he is only furnished with a skull duly prepared, and with a correct but brief description of the parts under review.—Say that his aim is somewhat higher—say that it is to a certain extent physiological; that is, to the extent of qualifying himself to read, with edification, the works of physiological writers; still he may acquire all that is necessary to enable him to do so, whether with regard to the solids or to the fluids, of the animal fabric, if he will be at the trouble of dissecting but a lamb, a hare, or a rabbit; or, rather, a number of such easily procured subjects, to give him dexterity of manipulation; or animals of larger dimensions, if he pleases, though he should never proceed to the dissection of a human subject, or engage himself in the more intricate and recondite details of anatomy.

There is yet another case in which the acquisition of a limited degree of knowledge in the anatomy of animals may be found to be useful. It is the case which we have made the very ground of our article on Zoology; namely, that of the vegetable physiologist who has had no opportunity hitherto, and has no opportunity now, of devoting himself to a regular course of zoological study. Yet the student who would learn, or the writer who would elucidate, the structure and living phenomena of the one kingdom of organized nature, will find his best help to success, to be the making of himself well acquainted with the structure and living phenomena of the other kingdom also. Life in all its aspects should be made the object of his study, that the several grades of vegetable and of animal being may be placed so as to shed a mutual light on one another. On this especial account, let the botanist who is yet unacquainted with the anatomy of animals, turn his attention to what follows. It may be the means of giving a beneficial direction to his future studies. For he will find that much may be achieved by his own individual industry, if he is furnished with but a few helps which are very easily procured.

In the department of the internal structure of animals, the most convenient distribution is that by which they are divided into Vertebrate and Invertebrate; that is, animals having a trunk furnished with a spine or back-bone; and animals having a trunk or body destitute of a spine or back-bone. The Vertebrate division comprehends the

following classes :—Mammalia, Birds, Fishes, Reptiles. The Invertebrate division comprehends the Mollusca, the Articulata, the Radiata, the Infusoria.

DIVIS. I.—VERTEBRATA.—*Class 1.—Mammalia.*—At the head of this class man stands alone without a rival. Most of the other genera that belong to it are Quadrupeds, and inhabit the land; but a few of them are fishes, and inhabit the ocean. The females are viviparous, and suckle their young; and hence the appellation of Mammalia. Further, in approaching the avenues that lead to the study of the Internal Structure of the Vertebrata, it might seem to be the most natural method to proceed from the surface to the centre, and so to begin with the Integuments. But upon a little reflection it will appear that the best method of procedure is to pass on *per saltum* to the fabric of the bones, as being a firm and substantial axis, to the surface of which the other organs are appended, or in the cavities of which they are lodged; and also to begin with the osteology of man, as a type or standard with which the student may compare the lower *grades*. Anatomists have prepared and described skeletons ready to his hand, and he can do nothing so good as to avail himself of their meritorious labours.

But previous to particular detail, which it will be for the student to follow up as he can, it may be useful to remark, now, that the osseous system is distinguished from all the other systems of the animal fabric by its greater solidity of substance, and by its want of pliability. Hence its peculiar aptitude to form the scaffolding or prop-work of the structure, which it does, not by a continuity of substance, but by the appropriate articulation of many individual pieces. Without this special provision no motion of the several limbs could take place. But there is a great variety in the size and structure of the bones composing the skeleton, which anatomists, by an arrangement of convenience, class and distinguish according to their dimensions of being long, flat, or short. [Bichât. Anat. Gen. t. ii. 139.]

The long bones occur chiefly in the apparatus of locomotion, where they form levers which the muscles move. The most remarkable of them are situated in the limbs—the longest being at the upper extremity of the limb, and the shortest at the lower extremity—as the upper arm, and the fingers; the thigh bone, and the toes. They enclose for the most part a medullary canal, but the ribs and phalanges do not. They are larger, and of a cellular texture at the two extremities; and smaller, and more cylindrical, and compact in the middle,—an arrangement that provides for strength of articulation, power of muscular motion, and symmetry of form—the muscles being, on the contrary, smallest at the extremities, and thickest in the middle.

The flat bones have but little relation to locomotion. They form

for the most part cavities, as in the case of the cranium and pelvis. They present of necessity two surfaces and a circumference. At the circumference they are thickest, and at the centre they are thinnest, even to a degree of transparency, which in some particular cases is such, that if you hold them up to the sun or to the light of a candle, you may see light through them. The two surfaces are of a firm and compact texture, and are called the tables. The substance lodged between them is cellular, and is called the *diplœe*.

The short bones are found in organs whose functions require both mobility of parts and solidity of structure, as in the vertebral column, the carpus and metacarpus, the tarsus and metatarsus. They make up in number what they want in size. Their shape is not uniform, but adapted to their situation and use. Internally they are cellular, and externally compact.

Bones are not often of a smooth and uniform surface throughout; but are, on the contrary, marked with various protuberances, known among botanists by the name of *apophyses* or processes, the product of their natural developement, and of *epiphyses* or parts added by accretion. Some processes are called mastoid—that is, nipple-like; some styloid—that is, dagger-like; some pterygoid—that is, wing-like; some clinoid—that is, bed-like; and some spinous—that is, forming a ridge. If the process is round and spherical, it is called a head: if it is flattened at the apex, it is called a condyle. They are destined for the purposes of articulation, or of the insertion of tendons or ligaments, which connect certain organs not otherwise capable of union,—a muscle never being immediately joined to a bone, [Never?] On the other hand, bones are often furnished with cavities, of which some are superficial, called glenoid—some deep, called cotyloid. Some are cavities of insertion, to give a larger surface of attachment to the tendons without increasing the size of the bone, as the pterygoid or wing-like cavities for the insertion of the pterygoid muscles—some are fossæ, or cavities of reception, as the superficial cavities of the inner plate of the bones of the skull;—some are grooved and covered with cartilage, in which the tendons slide;—some are cavities of transmission—that is, holes or openings to give passage to nerves and blood-vessels, as in the skull and vertebræ;—some are cavities of nutrition, as in long bones having marrow;—some are merely pores leading to the larger cavities, or to the sinuses, or they are pores that do not penetrate far. The chemical principles of bones are, gelatine and phosphate of lime; the phosphate giving them solidity, and the gelatine, elasticity and animality. The sensibility of bone in a sound state is as nothing; but in an inflamed or morbid state the pain it occasions is insupportable. All bones are accompanied with certain peculiar

organs or appendages which either cover them immediately, or connect them together. They are designated among anatomists by the appellations of periosteum, ligament, cartilage.

The *Periosteum* is a thin membrane, or envelope, adhering to and covering the external surface of every bone of the fabric, and assuming, in the bones of the skull, the denomination of pericranium. It is fibrous in its texture, and consists of two layers. By the inner layer it adheres to the bone, and by the outer layer it is united to the surrounding parts. It was at one time regarded as a continued sack containing the skeleton. But this idea is not correct. From bone to bone it is united only by the ligaments, at least in the moveable joints. It is moulded exactly to the form of the organ, except in the *dura mater*, where it forms the *falx*, a scythe-shaped process, issuing from the spine of the *os frontis*, and dipping into, and dividing the brain into what are called its two hemispheres. It gives attachment to muscles, or rather to tendons, and it transmits the vessels that are spread upon its surface into the substance of the bones, which it guards from the friction of parts that move over them, or from the beating of the arteries.

Ligaments are strong and flexible substances that join together the several moveable articulations of the fabric. They are composed of bundles of longitudinal fibres, sometimes round or flattened, and sometimes membranous, of a white or grey colour, firm, and but little elastic, as well as displaced with difficulty. Hence they are well adapted to secure the joints and to prevent luxations, which require, however, a combination of circumstances that does not often occur. Their fracture is next to impossible. Thus, in the horribly barbarous punishment, formerly in use, of tearing unhappy criminals to pieces by means of tying a horse or horses to each limb, and then making them pull in contrary directions, the rupture of the ligaments was often found to be impracticable till the aid of the knife was added. On some joints they are merely lateral, confining the motion to a particular side, and are of a round or flattened form, as in the lateral ligaments of the knee, the joint of which is a hinge. On others they are capsular—that is, forming a sort of cylindrical sack, open at both ends, but attached by the circumference of the openings to the surface of the articulated bones, near their point of junction, interwoven with the periosteum at both extremities, and including the joint. Such are the ball and socket joints of the arm and thigh, having motion in all directions. In some cases they form sheaths to tendons, the sheaths being partial or general—partial, if enclosing only a single tendon, as the sheaths of the flexors of the hand and foot,—and general, if enclosing several united tendons, as the annular ligaments of the wrist

and instep. In long-necked animals with hoofs, as the Horse, Deer, Camel, the cervical ligament—*ligamentum nuchæ*—is peculiarly worthy of remark. It originates in the dorsal vertebræ, which are elongated for its attachment, and is of special importance as contributing to the support of the head. [Carus, English Trans. i. 367.] Ligaments have but little sensibility in a sound state, but a very acute sensibility in an inflamed state, or if exposed to sudden and undue extension.

Cartilages are hard, elastic, and apparently inorganized substances, of a white colour, found chiefly in the articulations of bones, whether moveable or immoveable, as those of the limbs and of the cranium; or in the walls of cavities, which they help to form, as those of the nose, ribs, and larynx. In every moveable articulation there is, at the extremity of each bone, a thin layer of cartilage covering it, and giving facility to the movements of the joint. The inner surface adheres to the bone so closely that you may break the bone sooner than deprive it of its cartilage. The outer surface is covered with the synovial membrane, giving it polish and smoothness. The two cartilages of a moveable articulation are so formed, that in the middle point of their movement they meet by the whole extent of their surface. This is the position of rest. Their form varies according to the species of articulation. It is convex in the ball forming the head of the bone, and thickest in the centre; and it is concave in the socket forming the lowest part, and thinnest in the centre. In other joints they are of a uniform thickness, varying from a line to a line and a half. [Bichât.] The articulations of contiguous and immoveable bones are often effected merely by the insertion of a cartilage between the bones conjoined, where the mechanism of the parts suffices to give them strength and solidity, as in the bones of the face. At other times it is effected by means of sutures multiplying the points of attachment, as in the serrated and squamous articulations of the bones of the head; and at other times by means of implantation, as in the case of the insertion of the teeth in the jaws. Thus the immoveable articulations are secured merely by cartilages, while the moveable articulations require, besides, the connecting tie of ligaments, which are always proportioned in their strength to the quantity and quality of motion in the joint. Cartilages that help to form cavities are long, as in the ribs, or flat, as in the larynx; and are always covered with a fine membrane analogous to the periosteum, in which muscles are inserted. In a sound state all cartilages are white, and have no sensibility; but in a diseased state they assume a red colour, and are very sensible. They consist of albumen and water, with a small proportion of phosphate of lime. In the adult state of the human fabric they are pecu-

liarily elastic. If you thrust the blade of your dissecting-knife into a cartilage, and leave it there for a while, the edges of the opening will re-act upon it, and eventually force it out. [Bichât.]

Such is a brief and general sketch of bones and their articulations, taken chiefly from the *Anatomie Generale* of Bichât, and resting on that high authority.

But leaving generalities behind, it is now time for the student to begin to take a specific view of the bones of the human skeleton, directing his notice, first, to those of the head, which are divisible into the bones of the skull, or cranium, and the bones of the face; and then proceeding to those of the trunk, and of the extremities, superior and inferior.

The cranium, or skull, forms the upper and hinder portion of the head. Its shape is different in different individuals, but its general figure approaches to that of an egg, the large end answering to the occipital extremity. Its average length is about $6\frac{1}{2}$ inches, and its average breadth at the widest 5 inches. It is flattened at the sides, perhaps to give facilities to the functions of hearing and of sight. Its upper surface is smooth, but its under and outer surface is irregular, to give attachment to muscles, and passage to nerves and blood-vessels. It is covered with its pericranium, and forms in its interior a vaulted cavity for lodging and defending the brain, with its membranes, vessels, and nerves. It exhibits, besides, a variety of bumps and inequalities which the phrenologists have converted into the seat of specific faculties or attributes of mind. One is the seat of benevolence, another of devotion, another of hope, and another of fear; thus splitting into many parts what had in past ages been regarded as one and indivisible. As yet, however, the doctrine is but a theory, and has no legitimate foundation in fact. It is plausible, but not proved.

A novice might fancy that the *cranium* is composed of a single bone, as the shell of an egg is of a single expansion. Yet no supposition could be farther from the truth. It is formed, not by the curvature or convexity of a single piece, but by the union of a number of pieces, giving strength to its individual fabric, and security to the parts contained, and an additional means of resisting fracture in the more yielding texture of the uniting substance. The bones of the *cranium* are eight in number,—one occipital, one sphenoid, one ethmoid, one frontal, two parietal, two temporal;—to the comprehending of the precise form or figure of which, a human skull duly prepared is indispensable; and with such a *cranium* placed upon his table, and *Fyfe's Compendium of Anatomy* in his hand, let the student go to work.

Who would have supposed that there is a bone in the tongue? Yet

such is the fact; and without it the tongue would be but a very imperfect organ, as it would have no point of attachment for certain important muscles, on which much of its flexibility depends. It may be seen on a large scale in the tongue of the ox.

Having duly despatched the bones of the skull, face, and tongue, the student comes next to those of the trunk and extremities, for the full comprehension of which he must furnish himself with a human skeleton if possible. But if that cannot be done, then he must proceed to dissect for himself such other vertebrate subjects as he can most readily procure. Their parts will not correspond with those of the human subject in every minute particular, but their approximation to the type of man will generally be found sufficient to make the description intelligible.

Will it be asked why we recommend so urgently to the botanical student the study of the skeleton of the human fabric, seeing that plants are not furnished with any analogous *apparatus*, except in so far as you may make a skeleton of a leaf? [See the article SKELETON.] If plants are not furnished with any thing analogous to the osseous system of animals, it is because, being destitute of the faculty of locomotion, they do not stand in need of it; and because it is not wanted in the economy of vegetable life. Still the study of the bare skeleton is full of the soundest and most wholesome instruction to the botanical student. Is it nothing to have seen and contemplated *in situ* the several portions of the animal skeleton, together with the indissoluble bonds by which they are connected, whether for the purposes of motion or of support, or for the protection of parts contained? Is it nothing to have seen that nice and curious adaptation of means to the accomplishment of an end in view, which the contemplation of the skeleton presents, as being fitted by its superficies for the attachment of a muscular *apparatus*, and by its cavities for the reception of a sensitive, circulating, respiratory, digestive, and genital *apparatus*—all indispensable to the purposes of the animal economy, and all to be studied in sequence?

The Muscles.

Muscles are organs composed of an assemblage of soft and fleshy fibres, interspersed with the ramifications of blood-vessels, and of nerves, and attached mediately or immediately to bones or to tissues. They are divisible into two grand sections—voluntary and involuntary; or, according to the distinctions of Bichât, from whom the following account is chiefly taken,—muscles belonging to animal life—and muscles belonging to organic life. [Anat. Gen. System, Musc.]

The muscles belonging to animal life are, like the bones, divisible into long, broad, and short.

The long muscles are found chiefly in the limbs. They occur in bundles composed of parallel fibres of equal diameter, which are easily distinguished in the aggregate, but which elude, in the primitive fabric, the detection of even the most powerful lenses. These fibres do not divide or anastomose, but preserve always a straight line, except in the sphincter. Separated from the skin by a membranous envelope, and from the bones by the periosteum, the bundles are laid one above another, the more profound being confined by the more superficial, and each bundle by its own proper membrane.

Muscles are simple, if consisting of a single bundle; and compound, if consisting of several bundles. They are thickest in the middle, and smallest at the extremities; not by the widening of the diameter of the fibres, but by having many fibres that are shorter. But though muscles are the forces that move the bones, no muscle is immediately united to a bone. This union is effected through the intervention of fibrous prolongations, pervading or issuing from the extremities of the muscles, in the shape of white and shining cords, or of thin and fine membranes. In the former case, they constitute a tendon; in the latter, an aponeurosis of envelope or insertion,—of envelope, as in the *fascia lata* of the thigh—of insertion, as in the masseter, in which they connect the muscle with the bone, by means of a broad and flat expansion receiving the fibres of the muscle obliquely. They are of prodigious strength, and of inseparable adherence, whether to the muscle or to the bone. They have been thought to be merely prolongations of the muscular fibre itself, under a different aspect. But the chemical analysis of the two shows that they are essentially different. Tendons, by chemical analysis, yield scarcely any thing but gelatine. Muscles, besides gelatine, yield much fibrin, together with a peculiar substance called *ozmazome*, which is the principle that gives taste and smell to muscular flesh. [Allison's Outlines, 118.] Tendons are further distinguished from muscles proper, even by the colour; the muscles being of a red colour, and the tendon being of a glistening white. They have a strong analogy to ligaments, but they differ from them in their mode of attachment. Ligaments are attached to the periosteum by both extremities, if the tendon of the degastric is not an exception.

The broad muscles occupy, for the most part, the walls of cavities, as those of the thorax and abdomen, which they help to form, securing the internal organs, and aiding them in their functions. They occur chiefly in the form of membranes, as in the diaphragm, sometimes simple, and sometimes compound, and separated by layers of cellular tissue, but not often covered with an aponeurosis.

The short muscles have a thickness proportioned to their length and breadth. They occur where great force and little movement are wanted, as in the masseter, which is spread around the articulations of the lower jaw. They are often joined to one another either in the origin or termination, as in the hand and foot.

Muscular fibre is remarkable for its softness, and for its want of resistance to the touch, except in a state of excitement. In this it differs from the tendons with which it is connected. Exposed to air, and cut into thin slices, it dries; but if cut into thick slices, it putrefies. Exposed to stagnant water, it becomes white, and the water reddish. Exposed to running water, it is converted into a sort of tallow. The muscle of slaughtered animals, as it forms the bulk of the body, so it forms also an agreeable and nutritive food for man. That of the female is the most tender. But the grand and distinguishing characteristic of muscle as constituting a portion of the animal fabric, and claiming the particular notice of the anatomist and physiologist, is its unparalleled power of contractility—not the contractility of tissue, which it possesses in common with other tissues—but the contractility of life, to which it has a continual tendency, or to which it is easily stimulated. If a muscle is divided by means of a transverse section, the divided portions separate by shrinking towards their points of attachment. Also the antagonist of a divided muscle shrinks and draws the moveable member to which it is attached to its own side. Yet this is merely the contractility of tissue, and is not to be confounded with the contractility of life, whether it be the result of the stimulus of the will,—quick, sudden, and energetic; or of the organic susceptibility of the fabric,—slower, but not less certain. To this property of the muscular fabric, which is denominated its irritability, we may trace all the movements of the animal body, as well as of its particular members. Running, walking, leaping, flying, are all dependent upon the contractility of voluntary muscular fibre. Every voluntary muscle is furnished with an antagonist, unless we except the sphincter and diaphragm, which are partially voluntary at least. Thus every extensor has a flexor that acts in opposition to it. But if any muscle contracts, its antagonist relaxes, and thus muscular contraction unavoidably involves muscular relaxation.

The system of the involuntary muscles, or muscles of organic life, has much less extent than the last, and is more central in its situation, being found only in the breast, the abdomen, and pelvis. It does not enter the head. The voluntary muscles take generally a straight direction; the involuntary muscles take generally a direction that is bent or reflected. They form, for the most part, bags or pockets—cylindrical, as in the intestines; conical, as in the heart; round, as

in the bladder ; or irregular, as in the stomach. They are attached to the cellular tissue, but never to a bone ; and they have no tendonous fibres, whether of source or of termination. They are, for the most part, thin and membranous, and are composed of layers, but not of bundles, large in surface, but little in volume.

In the voluntary muscles, the texture is always the same, consisting of parallel fibres. In the involuntary muscle, the texture, together with the colour, is always varying, as in the heart, the bladder, the intestines, the fibres being short, and crossing in all directions ; or, where apparently long, as in the longitudinals of the œsophagus, being only a succession of short fibres joined together in the same line. They have less of cellular tissue among them than the other muscles, but they have many blood-vessels, exhalants, and nerves. They have great extensibility, as in the bladder and intestines ; and their extension is often very rapid, their contractility being in the same proportion. They have no antagonists ; but the substances they contain may be regarded as such, distending them in opposition to the contractile force. Their vital susceptibilities are not peculiarly remarkable. In a case of ceriæ of the sternum, in which the heart was laid bare, Haller applied stimulants to it, and irritated it, without the patient's showing any symptom of pain [First Lines] ; and the corresponding case of a young nobleman, as related by Harvey, shows also that the heart is insensible to touch. [Bell on the Human Hand.]

The student who is desirous of prosecuting the subject still further, and of making himself acquainted with the individual muscles, and their names, must still continue to dissect new subjects, and to make much use of *Fyfe's Compendium*.

Plants have not actual muscles, and hence no locomotion ; for an additional function requires an additional *apparatus*. But Dutrochet contends that they are furnished with muscular globules, sufficient to account for the movements of the *mimosa*, and of the apparently spontaneous movements which many other plants do evidently exhibit. —We admit that his facts give countenance to the opinion ; but it is a topic which lies open to discussion, and which the phytologist will investigate with care. [See the article NERVIMOTILITY.]

The Brain and Nerves.

The brain, in its general aspect, appears to be merely a mass of pulpy matter, marked with various convolutions, and enclosed in the cavity of the *cranium*, as in a place of safety, and of strength. Its soft and yielding texture, its susceptibility to lesion, and the extreme importance of its functions in the economy of life, required that it should be

well protected. Hence, the *cranium* is not the only organ by which the brain is defended from external injury. There are other helps and appliances to boot, both without and within. The hair, the skin, the muscles, the *pericranium*, are the outer defences; then comes the *cranium*—the main, the chief defence—first, by its hard and impenetrable texture, and then by its globular form, by which the impulse of a blow is dissipated, and spread over the whole surface of the skull, before it can reach the brain. The *dura mater*, the arachnoid, and the *pia mater*, are the inner defences.

If we take a view of the fabric of the brain *en masse*, we shall find that it is composed of two main portions,—the *cerebrum*, and the *cerebellum*—that is, the brain proper, and the lesser brain—to which we ought, perhaps, to add the spinal marrow also. For though anatomists have usually described it as being merely a prolongation issuing from the brain, and not as forming of itself a portion of the brain; yet, physiologists begin now to regard the *cerebrum*, the *cerebellum*, and the *spinal marrow*, as constituting, in their *ensemble*, but one organ. [Magendie, by Milligan, 103.]

In man, the brain has been thought to be larger, in proportion to the bulk of the body, than in any other animal. But this does not prove to be the fact; it is only larger in proportion to the nerves that issue from it. The average weight of the brain is said to be about two pounds and a half, avoirdupois. It attains to its full size at the age of seven, but does not seem to attain to its full weight till the age of puberty. [Wenzel's Tables. Magendie.]

Nerves are longitudinal filaments, or bundles of longitudinal filaments, issuing from the brain, or spinal cord, each enveloped in a fine membrane, and containing a sort of pulp or marrow [Bichât Anat. Gen. i. 181], though some physiologists doubt the existence of this envelope. [Magendie, by Milligan, 92.] The nervous system is double, and strictly symmetrical, the nerves issuing in pairs, one nerve for the right side, and another for the left. They have many anastomoses, and many branches or ramifications, by which they are distributed through, or over, the several organs to which they are sent. They are endowed with a very delicate sensibility. If a nerve is divided, or compressed, or irritated, by being laid bare, as in tooth-ache, it occasions the most acute pain—a pain specifically different from that of every other tissue or organ. In amputations, the patient will sometimes ask why the pain differs in the different portions of the section made by the knife. [Bichât Anat. Gen. i. 184.] Nerves have but little of extensibility, beyond what may be called their natural tone. If you pull a portion of nerve forcibly in different directions, you lengthen it but very little; hence it has but little of contractility, or of recoil, though cut through trans-

versely; and thus, in amputations, the nerve does not shrink in the proportion of the muscles, or skin, but remains projecting.

Bichât regards the nerves as forming two systems totally distinct—the one belonging specially to animal life; namely, the cerebral—sensible; the other, belonging specially to organic life; namely, the ganglionic—insensible; the former transmitting impressions to and from the brain, and including the nerves of the brain and spinal marrow; the latter connected with the functions of digestion, circulation, respiration, and secretion, and exemplified in the great sympathetic and its branches.

Plants have neither brain nor nerves; hence they can neither think nor feel. Yet Dutrochet regards them as being furnished with multitudes of nervous molecules—the primary source of all vegetable motion. This, like his doctrine of muscular molecules, is a topic that demands and deserves further investigation. [See the article **NERVIMOTILITY**.

The Heart and Blood Vessels.

The heart is an organ of a fleshy or muscular texture, and conical figure, situated on the left side, and in the lower part of the thorax, and invested with a serous bag or membrane, called the *pericardium*, which adheres by its base to the diaphragm, and by its upper part to the larger blood-vessels. Its position is somewhat transverse, with the base pointing to the plane of the *mediastinum*, and the apex to the space that intervenes between the fifth and sixth ribs. It includes within its fabric four cavities—two auricles, and two ventricles—an auricle and a ventricle posterior, or on the left side; and an auricle and ventricle anterior, or on the right side. It includes also the septa, by which the cavities are separated, together with the tricuspid and mitral valves. The walls of the cavities consist of three layers, one exterior, being a reflexion of the pericardium—one interior, thin and smooth upon the surface in contact with the blood; and one situated in the middle, muscular, and essentially contractile. [Magendie, by Milligan, 336.] Thus the heart is fitted to give ingress and impulse to the circulating blood. The auricles receive it, the ventricles expel it; and hence it is regarded as the prime centre of the vascular system—the source of the arteries, and recipient of the veins.

The arteries issue immediately from the ventricles; the pulmonary artery from the right ventricle, and the great artery, or aorta, from the left ventricle. They may be said to be tubes or cylinders, consisting of three coats or layers: an exterior layer, strong and cellular; an interior layer, fine and smooth on its exposed surface; and a middle layer, or “coat of muscular fibres, which are in general

imperfect circles." Such is the description and doctrine of Haller [First Lines by Cullen, xxx.], which anatomists in general adopt. Yet Magendie denies the muscularity of the fibres in question; and says they are elastic, but not muscular. [Magendie, by Mill. 337.] We must leave this point to be decided by the adepts.

After leaving the ventricles, the artery soon begins to subdivide, and to ramify in all directions, into thousands of branches, diminishing as they recede from the heart, and traversing the whole fabric of the body, till, at last, they terminate in the extremity of their course in the most minute capillaries; some ascending to the neck and head; some diverging to the lungs and *thorax*; some to the arms and hands, where they terminate in the tips of the fingers; and finally, some extending downwards till they reach the thigh, leg, and foot, where they terminate ultimately in the tips of the toes.

The veins which commence in the capillaries are also tubes or cylinders, consisting of three coats or layers; the outer layer cellular, thick, and tough; the middle layer said to be composed of longitudinal fibres; the inner layer thin, and smooth upon the surface in contact with the blood. They very generally run parallel with their corresponding arteries; yet they often leave them, and affect more the surface of the fabric. They unite and inosculate as they approach the heart, till at last they enter the auricles in trunks comparatively large;—that is, for the general system, through the medium of the two cavas—the ascending cava from the lower extremities, and the descending cava from the upper extremities—and for the pulmonary system, through the medium of the pulmonary veins. Their distribution is similar to that of the arteries, each artery having, in general, its corresponding vein. But to this rule there are some exceptions.

Plants have neither a heart, nor arteries, nor veins. Hence they can have no circulation similar to that of animals. They have a peculiar distribution of fluids, it is true, suited to the wants of the individual, and to its manner of growth; but it is an abuse of the term to call it a circulation.

The Nostrils and Respiratory Organs.

The nostrils are the two openings formed by the *septum marium*, which lead through the interior cavities of the nose to the fauces. At present we regard them merely as passages, giving ingress to the air inspired, and egress to the air expelled, by the lungs. In man the mouth may also be regarded in the same light; for if the passage through the nostrils should happen to be stopped up, as by a cold, or by any internal swelling, or by the will, or against the will of the indi-

vidual, the function of respiration can still be carried on by the mouth. In either case the passage leads ultimately to the larynx,—an assemblage of cartilages, so joined by connecting muscles and ligaments as to form a peculiar cavity that receives the air from the *fauces* and transmits it to the lungs, or the contrary.

From the *larynx* downwards the canal leading to the lungs takes the name of the *trachea*, *arteria aspera*, or wind-pipe, which, after descending to a level with the third or fourth vertebra of the back, divides into two main branches, known by the appellation of the right and left bronchial tubes respectively, through the medium of which it communicates with the lungs.

The lungs are two spongy and vascular organs, of a greyish colour, and of rather a pyramidal shape, situated in the thorax—the one on the right side larger, and the other on the left side smaller, and exhibiting a parenchyma composed of an infinite number of little air cells. They are divided and subdivided into subordinate lobes or lobules, of an indefinite form and dimension. Each lung is besides invested with its own proper membrane or envelope, as by a fine epidermis, united to it by means of a cellular tissue. The right bronchial tube enters the right lung, and the left bronchial tube enters the left lung, each dividing and subdividing, and sending off secondary branches that enter and traverse the lobes and lobules till they terminate at last in the cells, which are invested and connected together by a fine and mucous web. Thus, the air inspired is distributed throughout the whole extent of the lungs, and is finally brought into close approximation with the extreme capillaries, whether of the arteries or veins, that are distributed in innumerable ramifications over the mucous and investing web.

Plants have a respiratory apparatus in the leaves and green parts. Indeed, the leaves have, from time immemorial, been regarded as the lungs of plants. But the opinion was still left as a matter of doubt, till the illustrations of pneumatic chemistry proved it to be a fact. The leaves inhale and evolve, alternately, both oxygen, and carbonic acid. See the articles on the elaboration of these gases.

The Mouth and Digestive Organs.

The mouth is an organ so well known to every body as scarcely to stand in need of a definition. We must not, however, leave it altogether untouched. It is the opening formed by the lips, cheeks, and jaws, with their adjuncts and integuments. It contains the tongue, an organ of a fleshy contexture, and oblong or wedge-like shape, which lies in the middle of the mouth, with its tip resting on the front

teeth, and its base concealed within the fauces. It is changeable, however, to almost any kind of figure by the action of its muscles, and readily directed to any part of the mouth. Its upper surface is covered with small papillæ; and its under surface is divided longitudinally by a medial line. The upper boundary of the mouth is the hard palate, from the posterior portion of which the soft palate, or *velum palati*, together with the *uvula*, depends. These parts may be all seen by inspection into the opened mouth, as also the amygdalæ, or tonsils, situated at the entrance of the fauces.

The fauces, or pharynx, or top of the throat, is the common cavity that is situated behind the *velum palati*, to, or from which, there enter, or issue seven passages—the two posterior nostrils—the two Eustachian tubes—the mouth, the larynx, and the œsophagus, in which it terminates downwards. Hence we may regard the pharynx as the first and anterior portion of the alimentary canal; being merely a bag-like or funnel-like prolongation of the membranes that line the mouth, surrounded on all sides by muscular fibres. The second portion is the œsophagus or gullet—an organ very sensible, and very elastic, and very peculiar in its structure, which may be regarded, however, as exhibiting a type of the structure of all the portions of the alimentary canal. It is to be regarded as being merely a tubular prolongation of the bag of the pharynx, adhering to and following the course of the vertebral column, till it has passed the lungs and heart, when, bending forwards and a little to the right, it perforates the diaphragm, and enters the abdomen and stomach.

The stomach, which may be regarded as an expansion of the œsophagus, is a large and membranous sac situated in the upper region of the cavity of the abdomen, and destined for the reception of the food and drink that has been swallowed. When empty, it shrinks and contracts upon itself; but when full, it has a slight resemblance to the inflated paunch of a bag-pipe; its largest diameter [being transverse, and its largest curvature being on the left, widening till [it reaches the insertion of the œsophagus, which is usually denominated the upper cardiac orifice, and narrowing from that point till it ends in the pylorus, its opening of outlet on the right. It is the third portion of the alimentary canal, and is attached to the diaphragm by the *peritoneum*, which expands over it by a production that terminates in the great *omentum*.

From the *pylorus* the intestines may be regarded as taking their origin. They form the canal that is denominated the gut, which, in the human subject, is about six times the length of the body. They are divided into the small intestines and the large intestines. The small intestines include the *duodenum*, the *jejunum*, and *ilium*, in the

order in which they stand; the large intestines include the *cæcum* the *colon*, and the *rectum*, in the same order.

Plants have no digestive *apparatus* strictly so called; because they have no organs analogous to the stomach and intestines of animals. Yet, M. Delandolle [Phys. Veg. t. iii. 1360], with some other botanists of reputation, ascribe to them what they call a digestive system; by which we are to understand, as I believe, those parts or organs through which the sap ascends, or is impelled, till it is converted into *cambium*. Yet I do not find that this doctrine is well received by botanists in general. Dr. Lindley takes no notice of it, neither does Professor Henslow.

The Sexes and Genital Organs.

Though the existence of sexes in vegetables has been established only in modern times, yet the existence of sexes in animals has been always acknowledged. "In the beginning God made man, male and female." [Genesis i. 27.] The object of sex is the propagation of the species, or the generation of a being like the parent; and to the discharge of this function, each sex must contribute its part,—the male to give—the female to receive; for which special and important purpose each sex has its own proper organs.

Plants, or at least the great mass of plants, are, as every body now knows, furnished with the attribute of sexuality, and, by consequence, with what the zoologist styles genital organs, which the physiologist will compare, no doubt, with those of the animal subject, that he may see by what a diversity of means nature is capable of accomplishing the same ends, in the manner best suited to the circumstances and character of the class or species to be furnished with such organs. But in speaking or writing on this delicate topic, let the student beware of breaking through the rules or *decorums* of civilized life, by the use of terms borrowed from the anatomy of animals, merely for the sake of showing how very forward he is in his zoological studies. If he does so, he will be sure to give offence to some chaste and delicate ear. Let him therefore avoid it with the greatest scrupulosity. Plants destitute of sex entirely, have their propagation effected, not by seeds, but by sporules.

The Absorbents and Exhalants.

The Absorbents.—The absorbents are small and capillary tubes taking up and conveying fluids, which they conduct to peculiar channels for peculiar purposes. They are usually divided into two species—lacteals and lymphatics.

The lacteals are found in and among the intestines, and are destined to imbibe by small orifices the nutritive portion of the chyle, which they convey into the circulation by pouring it into the thoracic duct.

The lymphatics, like the lacteals, absorb and convey a peculiar fluid, and conduct it into the circulation for a different purpose,—that is, they obtain it chiefly by liquifying such particles of the solid fabric as have now become effete, and by conducting it to the circulating medium, for the purpose of final expulsion. The spongiolæ and stomata of plants are their absorbents.

The Exhalants.—Bichât asserts the existence of exhalants [Anat. Gen. ii. 67]; yet Magendie says their existence is altogether gratuitous [by Milligan, 447], because, although exhalations, both mucous and serous, are found in, and thrown off by, the several membranes, yet no one has ever seen an exhaling *apparatus*. We do not think there is much force in this argument. For that which cannot be seen, may often be legitimately inferred. We cannot see the wind; but what would be thought of the man who should, therefore, deny its existence? The pores or stomata of plants are their exhalants.

The Glands.

The glands are organs that secrete, from the arterial blood, a fluid which they discharge by one or more peculiar openings, either so as to expel it immediately from the system, or into such cavities as communicate with the exterior of the body.

Such is the definition of Bichât; but it is evidently defective, as excluding the conglobate and lymphatic glands, and including merely the mucous and conglomerate,—that is, the liver, the kidneys, the testicles, and the salivary glands. They are single, as in the liver; or in pairs, as in the kidneys; and are each furnished with a proper and peculiar tissue, calculated for the secretion of a peculiar fluid.

Plants are furnished with organs called glands, which the student will have an opportunity of comparing with the glands of the animal system.

The Membranes.

Membranes are fine, thin, and net-like tissues, enveloping or lining the several organs or vessels of which the fabric is composed, or constituting vessels of themselves. They are usually divided into two species—mucous and serous.

Mucous membranes occupy the interior of such cavities as communicate with the skin by means of openings leading to the surface,—as the mouth, the œsophagus, the stomach, the intestines, the bladder, the ureters, the urethra,—all organs of excretion. Thus there are

many organs, but as they are all continuous with one another, or at least such of them as are common to the same grand opening of entrance or of outlet, they may be regarded as consisting of two classes—the gastro-pulmonary and the genito-urinary [Anat. Gen. Syst. Membraneux]; the former entering by the mouth and nose—the latter by the urinary apparatus.

Mucous membranes are in their nature glandulous. They form the grand emunctory of the animal economy, by which the waste residue of the materials of nutrition is expelled from the system, and they are furnished with innumerable blood-vessels, as may be inferred from their colour. They are endowed with much sensibility, at least such of them as are near the orifice of outlet, as the palate; but their sensibility is blunted by habit, as in the use of tobacco; though in the interior they discover no sensibility, except when excited through inflammation. Are there exhalants in the mucous system? Bichât has no doubt of it from its analogy to skin. [Anat. Gen. ii. 516.] The perspiration of the pulmonary system is the very analogue of that of the skin. The one augments or diminishes as the other diminishes or augments. Let the cutaneous perspiration be obstructed, and the lungs are immediately oppressed.

Serous membranes occupy, for the most part, the exterior of the organs which the mucous membrane lines—as the stomach, intestines, lungs. They are not continuous, like the mucous membranes, but are isolated on each organ. Thus each membrane represents a bag or sac, without any opening, spread upon the organs which it embraces respectively, and enveloping them by its outer surface, but never admitting them into its cavity. Bichât illustrates it by comparing it to a double night-cap that folds up into itself, and covers the head only by presenting to it part of its outside surface. [Anat. Gen. ii. 544.] The pericardium is a good example.

Though plants are not furnished with any membranes corresponding exactly whether to the mucous or serous membranes of the animal fabric, yet they are furnished with membranes suited to their vegetable character, and destined to invest peculiar organs, wherever the case seems to demand it. Thus the ovulum, even in its origin, is invested with its two membranes, which are converted afterwards into testa and secondine, or primine and secondine; and the embryo on its first appearance is vested with what some botanists call the embryonic sac, which is afterwards absorbed. Besides, of what is the vascular or cellular tissue of vegetables formed, if not of membrane?

The Integuments.

All living bodies are furnished with one or more integuments. They

defend the fabric; they resist the action of acrid or corrosive substances; they prevent the dissipation of fluids; and they form an appropriate instrument of communication with the external world. Plants have a bark, or merely a simple membrane;—fishes have scales or shells;—birds have a skin and feathers;—man has a skin covered with a fine epidermis, that envelopes the whole of the body, and serves as a fit and comely limit to the fabric. It adheres closely to the parts on which it is spread; moulds itself to their shape; follows them in all their inequalities; projects when they project, and retreats when they retreat; adding smoothness to the surface and beauty to the form, and covering not only the whole of the superficial parts, but entering into the main openings that lead from the surface to the interior of the fabric, as the mouth, the nose, the anus; as well as giving origin to the mucous system, under the form of a fine, smooth, and delicate membrane, whose commencement is marked by a line of red. It is traversed by a variety of folds, the result of different and specific causes. Some depend upon the direction and action of muscles that seem to be incorporated into the substance of the skin, as those of the forehead, and those around the eye and mouth. The muscles contract, but the skin, not having the property of contracting along with them, is left in the form of a wrinkle. Others depend upon the movement of muscles, though not incorporated into the substance of the skin, as those of the soles of the feet and palms of the hands—the results of the action of the flexor muscles at the several rows of phalanges; as also on the back of the hands and feet in the line of the knuckles. Others depend upon the peculiar arrangement assumed by the papillæ at the ends of the fingers—the principal organs of touch. Lastly, some are induced by age,—the plumpness of youth having disappeared, and the skin having lost its power of recoil. [Anat. Gen. Syst. Derm.] The skin may be regarded as consisting of two distinct and separable portions,—namely, an *epidermis*, or external cuticle; and a *corion*, or internal mass.

The epidermis is a fine, thin, and transparent membrane, spread on the surface of the corion, to which it firmly adheres. But it is readily detached by inflammations, whether natural or artificial, as by erysipelas or vesication. It often detaches itself in the form of little scales, which has given origin to the idea of its being composed of a union of individual scales merely—an idea that does not seem to be well founded. It is perforated by an innumerable multitude of pores passing through it in an oblique direction, as may be perceived by the bend of the projecting hairs—or presumed from the bag which it forms in blisters,—the oblique position of the pores, as they lie close pressed, preventing the escape of the fluid. It is nearly of the same

tenuity throughout, except in the soles of the feet and palms of the hands, where it acquires a considerable thickness, and may be detached even in slices, if your cutting instrument is pretty sharp, as is often done by the trade, and others, in trying the edge of a razor. Thickness destroys its transparency. Hence the soles of the feet of a negro are whitish, because the black colour is not seen through the thickened epidermis. It presents no apparatus of fibres or of vessels, but seems altogether inorganic ; and if traces of vessels do sometimes appear on its inner surface, they are merely, as Bichât thinks, adhering fragments of the vessels of the corion, rather than vessels belonging to its own structure. [Anat. Gen. ii. 748.] The action of the air does not much alter it when detached. Water whitens it on the living subject, and causes wrinkles in it, as may be seen on the hands, after washings or bathings long continued. Bichât thinks it imbibes part of the water ; but when it becomes dry it resumes its former appearance. It does not undergo racornissement by fire, as other animal substances. Nitric acid turns it yellow, and ultimately destroys it. It has but little of expansibility, and hence it is apt to crack in cutaneous tumours. It has no sensibility, and is incapable of acquiring it. It is in a state of continual waste and repair. If it sloughs it will come again ; and if you scrape it off it will come again. But it will not come again, except upon the natural surface of the *corion* ; for the cicatrice that is formed upon the surface of a wound with loss of substance, is not a true and legitimate epidermis. It has a different aspect, and a different texture, and cannot, like the epidermis, be raised into a blister. The nails are regarded as being a sort of epidermis peculiar to the extremities of the toes and fingers. They consist of three portions—a posterior portion, continuous with the general epidermis, and concealed under the skin ;—a middle portion, free by one side ;—and an anterior portion free by both sides. They consist of several layers like those of the soles of the feet, and, if detached, are regenerated like the epidermis ; like which, also, they are without pain.

The *corion* is composed of two layers—an outer layer, which has been called the *rete mucosum*, and an inner layer, which may be called the *cutis vera*, interspersed with numerous blood-vessels, nerves, exhalants, absorbents. The *rete mucosum* has been described by Malpighi and some others as a layer that might be isolated and detached. Bichât could not succeed in the operation of detaching it. [Anat. Gen. ii. 664.] But he regards its existence as proved by injections, and the network as originating in the capillaries in which the arteries terminate. The fluids injected give colour to the internal parts, and so doubtless do the fluids that pervade the corion in its natural state. Hence the colour of the different races of men—the black, the tawny,

the white. In blacks the rete mucosum is more conspicuous than in whites, and is said to have been detached entire. But in white men some anatomists doubt its existence altogether. "We have sought for it in every way, but without success." [Encyc. Brit. Sup. i. 266.] The *cutis vera*, which is adjacent to the interior parts, and attached to them by means of a bed of cellular tissue, is itself chiefly cellular and sponge-like in its structure, with traces of interspersed fibre, more or less distinct, and of a white and shining appearance. It differs much in thickness in different parts of the body. On the *cranium* it is thicker than on the face; on the back parts thicker than on the front parts; and on the soles of the feet it is the thickest of all. It is supplied with blood-vessels from the subcutaneous or cellular tissue; and with nerves from the same source, penetrating and traversing the cutis in their most minute ramifications, till they terminate at last in an infinite number of papillæ, which, piercing the *rete mucosum*, place themselves in contact with the epidermis, and are the organs of tact, and of touch,—feelings that are not to be confounded. In tact we are passive, in touch we are active. The existence of the absorbents of the corion is not demonstrable to the eye; but it is indubitable from the fact of the absorption of mercury, and imbibition of various other fluids. The same thing may be said of its exhalants. Their existence is proved by natural perspiration, by bloody transudations, and by injections.

Thus the skin is an organ indispensable to life, and to comfort. It is endowed with an extreme sensibility; and if you doubt it, remove the cuticle. Its smoothness and softness are invaluable ingredients in female beauty. But it is the seat of many maladies.—By habit it may be made to bear "all seasons and their change." The Scythian is all face. The European clothes all but the face. The *costume* of India shocks our feelings; but custom reconciles us to every thing. Subjacent to the corion there is in many animals a sort of muscular layer called the *fleshy panicle*, which isolates the skin, and renders it capable of a variety of movements. By this the lion erects his mane, and the horse moves and agitates the whole surface of his body. In man there are traces of such an organ, but only in the face, where the passions have their chief manifestations.

Besides the covering of the skin, many animals have an additional and exterior covering of hair. In them it serves as a clothing to resist the extremes of heat and cold; but it diminishes, at the same time, their susceptibility to the contact of external bodies. In man it is to be regarded as a partial covering, that leaves the greater part of the skin bare; thus rendering him more susceptible to impressions, and enlarging the sphere of his pleasures from without. The parts of man

that are covered with hair are, the cranium, the chin, the arm-pits, the pubes. The hair of the head grows to a great length, particularly in females—black, white, or red. It is very ornamental, and females, young and old, know how to avail themselves of its various susceptibilities, to give additional grace to feature, or to form. The beard is peculiar to males. It appears at the age of puberty, of which it is a sign. It is shorter than the hair of the head, and more given to curl. It is black or red. The hair of the pubes is of the nature of beard, and is generally dark. The hair of the arm-pits is analogous to that of the pubes; and of that of the eye-brows, we may say the same thing, the individual hairs of which issue obliquely, and in the aggregate form a shade to the eye. The eye-lashes issue from the extremity of the eye-lids, and are at the same time an ornament and a defence. The hair of the trunk is chiefly on the breast; and that of the limbs, on the outside of the fore-arm, and back of the hand. Bichât remarks that all openings into the interior, as the mouth, the nose, the eye, the ear, the anus, and sometimes even the nipples, are surrounded with hair. To this rule the urethra is an exception, but it has its prepuce to cover and protect it.

Each hair is inserted in the tissue of the skin by its root, enclosed in a little bag or bulb, as may be seen by pulling one out. If examined closely, it will be found to consist of two parts—one external and forming a tube; the other internal, and occupying the centre. The former is of the nature of the epidermis—without life or sensibility. The latter consists of two sets of vessels; one containing the colouring fluid of the hair, the other a fluid that has a sort of circulation—vital, but not animal—except in the case of the disease called *plica polonica*, in which it is said that it bleeds if cut. [Anat. Gen. ii. 788.] The hair is affected by the passions. Sorrow has been known to change the colour of a man's hair even in a single night; and every body knows that fear makes one's hair to stand on end. We see that cats and dogs can bristle up their hair when irritated; but perhaps this is owing merely to the action of the *panicule charnue*. The extensibility and consequent contractility of hair is not great; but the strength of a single hair is great, and will support a great weight. In infancy it is downy; in youth it is smooth, sleek, and abundant; but in old age it turns grey, and falls off.

The integuments of the plants are the bark, and its epidermis; but the integument of the leaf, or flower, is an epidermis merely.

The Senses, and Organs of Sense.

The senses are the organs by which the individual communicates with the external world. Each sense has a peculiar apparatus, calcu-

lated to convey peculiar impressions, moving us with pleasure or affecting us with pain. The senses have been from time immemorial regarded as five in number; though, among the vulgar, we often hear of the seven senses; and among anatomists we sometimes hear of a sixth sense, as the muscular sense of Bell. [On the Human Hand.] But for the present we advise the student to rest content with the number five,—touch, taste, smell, hearing, sight.

Touch.—By touch we become acquainted with the following qualities or properties of the bodies that surround us:—Heat, or cold; hardness, or softness; smoothness, or roughness; penetrability, or impenetrability; size, figure, weight. Its seat is in the skin,—that is, in the *cutis vera*; but its susceptibility is not the same throughout. It is distinguished into two degrees, at least; the lower degree being diffused over the skin generally; the higher degree being confined to particular portions of it, as covering particular organs. The former is denominated *Tact*, and is common to the head, neck, trunk, and general mass of the limbs. The latter is denominated *Touch*, and is confined chiefly to the palms of the hand and soles of the feet, but especially to the ends of the fingers.

Taste.—The faculty of taste is analogous to that of touch, as well as its mechanism. The body tasted is in fact touched. The tongue is the chief organ by which the faculty acts, the palate being a subordinate agent. The qualities which the tongue detects are savours, denoted by the terms sweet, sour, bitter, acrid, pungent, insipid; and the bodies that excite the sensation are said to be *sapid*,—that is, stimulating to the tongue or palate. Yet the tongue cannot discharge its function of judging of savours except through the medium of the mucous fluid which it secretes, and of the *saliva* with which it abounds. Hence we should perhaps infer that taste implies some slight and partial solution of the body tasted.

Smell.—Smell is essentially different both from touch and taste. It has its seat in the nostrils, and the qualities of which it judges are odours and flavours, agreeable or disagreeable, fugacious or permanent, aromatic, mild, pungent, fetid. But in smell there is no contact of the odoriferous body with the organ of sense. There is merely the contact of certain particles of extreme tenuity, that escape from the surface of almost all bodies in nature, and diffuse themselves throughout the fluid of the surrounding atmosphere. The same species emits uniformly the same *effluvia*.

Hearing.—The ear is the seat of hearing, or the organ through which we acquire the sensation of sound. The contact of the sonorous body is not necessary to its production, but merely the intervention of atmospheric air, on the undulations of which the impression is conveyed.

Vision.—As the ear, the organ of hearing, does not require the contact of the sounding body, so the eye, the organ of vision, does not require the contact of the body seen. In either case, the sensation is excited by means of impressions conveyed to us through the intervention of a peculiar medium; and what the aerial fluid is to the ear, light is to the eye—the cause and occasion of vision.

As plants are destitute of the attribute of sensation, it would have been of no use to confer upon them organs of sense. An eye would not have given them sight, nor an ear hearing. As well might you expect the marble statue to see or to hear, by placing human eyes or ears in sockets or hollows excavated for them on purpose. But plants are furnished with every organ necessary to their state or rank in the scale of being. The lowest plants, like the lowest animals, have what we are led to regard as a very imperfect organization. But they have many rising gradations among themselves, participating in the dignity that life confers, and rivalling the productions of the animal kingdom, whether in beauty or in utility.

We have now finished the hasty sketch which we intended to exhibit of the approaches that lead to the study of zoology as connected with botany; and if the student wishes to turn to immediate account the knowledge which we will presume he has acquired from the study of Fyfe's *Compendium*, let him procure Alison's or Mayo's "Outlines," together with Magendie's "Elements" for function and physiological research. He will find, in the perusal of them, much both of instruction, and of gratification. But if he wishes, previously, to extend his enquiries to the remaining classes of the *Vertebrata*, or to the several classes of the *Invertebrata*, he can do nothing better than take up Fyfe's fourth volume, and to go to work as before. He will now find himself in the department of Comparative Anatomy, and in the *Vertebrata* will have an opportunity of noticing such peculiarities of structure as are necessary to fit them for the *grade* and condition in which they are located in the scale of animal life, without losing entirely their resemblance to the type of man. In the *Invertebrata* he will find such deviations from the type of man as will efface all traces of similitude of structure, and exhibit an organization low, indeed, in comparison. But as he descends still lower in the scale, he will find animals that exhibit closer analogies to plants, or greater capabilities of injuring or of destroying them, and hence claiming more particularly the attention of the botanist.

It is in this department that he will meet with the tribe of insects (those little devourers of cultivated crops or plants), which commit such ravages in our corn and turnip fields, and in our vineyards and hop plantations. It is fit that the botanist should make himself com-

petently acquainted with the whole tribe or family, together with their names and habits, but especially with the food which the several species prefer, that he may know beforehand what plants are the most likely to be assailed by their attacks, and what is the remedy or preventive, if a remedy or preventive is known. [See DEPREDATIONS OF ANIMALS OR INSECTS.] We ought not, however, to overlook the reverse of the picture; many insects are eminently serviceable to man,—as the bee by its honey, and the silkworm by its *cocoon*, administering to our comforts and luxuries, both with regard to our food and our clothing.

Here the student will find, also, that group of entities which were so long regarded by naturalists as combining, in the same individual, both plant and animal; and hence denominated *Zoophytes*. In the works of the earlier writers on this subject, it will be found that the ground of the above opinion, was the very singular mode in which many of them, as the *Polypi*, effect the propagation of the species; namely, through means of buds that issue from the body of the parent, and ultimately fall off, each becoming a new individual; or through means perhaps still more singular—that is, merely through the instrumentality of section, as you may multiply a great proportion of undoubted plants. In the works of our more modern physiologists, it will be seen on what ground the now prevalent opinion rests, by which the entities in question are regarded as being merely animals endowed with the faculty of elaborating and of excreting the substance which forms the fabric of their specific habitations, and assumes the figure and aspect of a plant. Still it may be doubted whether physiologists are in a capacity to say of any living entity, Here, vegetable life ends—or, There animal life begins,—or, Here the two are conjoined. For in this case, as in many others, there seems to be a considerable extent of debatable ground; so that if nature has not assigned to the two kingdoms of organized being any very express or tangible limits, man will be found to have instituted his distinctions in vain. The trial by fire is regarded as a good test. Animal substances in a state of ignition exhale a strong and phosphoric odour, which no vegetable substance has been known to do.

Finally, there is in this department, also, a tribe of entities—namely, the *animalcula infusoria*, which have been generally regarded as located at the very bottom of the scale of animal existence, and which were long looked upon as consisting merely of a pulpy mass, without any organs, external or internal, taking up their food by imbibition, and digesting or elaborating it, nobody knew how. It was a doctrine that could not well be received without some mixture of doubt. Yet it was thought to have been firmly established by Müller, who laboured most assiduously, with a view to ascertain the true structure of these

minute beings, and threw much light upon the subject. But Ehrenberg, not satisfied with the doctrine of Müller, and presuming that these nimble little creatures could not possibly be destitute of all organs whatever, undertook the investigation of the subject *de novo*; and in this undertaking he was eminently successful; for, by the aid of lenses of a higher magnifying power than any that had been previously employed, he ultimately arrived at the discovery of the fact, that instead of being destitute of all organs whatever, they are furnished with a multiplicity of organs, having both a mouth, and a digestive apparatus, consisting of four stomachs at least, together with traces both of a muscular and nervous *apparatus*. This new view of the structure of the Infusoria seems to be regarded by zoologists as being strictly correct, while it gratifies at once our appetite for new discovery, and extends the boundaries of zoological science.

If there should, after all, be doubts remaining, still it will be the business of the physiologist to proceed, and to persevere till all doubt shall have been removed, if the removal of all doubt is practicable; and, as a motive or inducement to diligent application, we will wind up our remarks with the very encouraging, though very trite apothegm, which says,—*Nil tam difficile est quod non solertia vincat*; and which implies that—ALL DIFFICULTIES YIELD TO ASSIDUITY.

FINIS.

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